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AUTHOR	Nelson, Barbara Ann
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ABSTRACT

Two studies were designed to identify two learning styles. Study I looked at the effect of the analytic-global cognitive style on the acquisition of three geometry concepts presented through written lessons which did or did not contain verbal emphasis of relevant attributes. A total of 108 analytic and global seventh grade students were identified by the Hidden Figures Test. Results of the lessons showed that analytic students performed better than global students and that students studying the emphasis lesson performed better than those studying the no-emphasis lesson. Study II looked at the effect of the reflectivity-impulsivity cognitive style on the acquisition of three geometry concepts presented through discovery or expository lessons. A total of 107 reflective and impulsive seventh graders were identified by the Matching Familiar Figures Test. Results of the lessons showed that students studying expository lessons performed better than those studying discovery lessons and that expository lessons did not benefit impulsive students more than reflective students. (Author/DT)

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Technical Report No. 234

EFFECTS OF THE ANALYTIC-GLOBAL AND REFLECTIVITY-IMPULSIVITY COGNITIVE STYLES ON THE ACQUISITION OF GEOMETRY CONCEPTS PRESENTED THROUGH EMPHASIS OR NO EMPHASIS AND DISCOVERY OR EXPOSITORY LESSONS

Report from the Project on Individual Differences Among Learners

by Barbara Ann Nelson

Herbert J. Klausmeier, Frank Hooper,
Frank H. Farley, and Joel R. Levin
Principal Investigators

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

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STATEMENT OF FOCUS

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints--financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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ABSTRACT

Studies were designed to identify two learning styles. "Learning style" was defined as the interaction between an organismic variable and an instructional treatment. The organismic variables, the analytic-global cognitive style and the reflectivity-impulsivity cognitive style, which were chosen, were hypothesized to affect two operations involved in attaining a concept at the formal level. These operations are discriminating attributes and inferring the concept. It was hypothesized that the analytic S would be able to discriminate attributes better than the global S and that the reflective S would be able to infer the concept better than the impulsive S. Lessons which drew attention to the relevant attributes were designed to compensate for the global S's inability to discriminate attributes and lessons which supplied the inferences were designed to compensate for the impulsive S's inability to infer the concepts.

Study I was designed to look at the effect of the analytic-global cognitive style on the acquisition of three geometry concepts presented through written lessons which did or did not contain verbal emphasis of the relevant attributes. The verbal emphasis consisted of a general statement drawing attention to the relevant dimension and questions drawing attention to values along that dimension. Analytic and global seventh graders were identified by the Hidden Figures Test. They then studied an introductory lesson and a geometry lesson containing or not

containing verbal emphasis during class periods on two consecutive days. A test was given on the second day after completion of the lesson.

Study II was designed to look at the effect of the reflectivity-impulsivity cognitive style on the acquisition of three geometry concepts presented through discovery or expository lessons. Under the discovery method four positive and three negative examples were presented for each concept and S was required to infer how positive examples were alike and how negative examples differed from positive examples. Under the expository method a definition was provided, followed by the positive and negative examples of the concepts. S was told why positive instances were examples of the concepts and why negative instances were not examples of the concepts. Reflective and impulsive seventh graders were identified by the Matching Familiar Figures Test. They then studied an introductory lesson and a geometry lesson presented in the discovery or expository mode during class periods on two consecutive days. A test was given on the second day after completion of the lesson.

The results for Study I were:

1. Analytic Ss performed better than global Ss.
2. Ss studying the emphasis lesson performed better than Ss studying the no emphasis lesson.
3. These results were most evident on questions which assessed the discrimination of attributes.
4. Emphasis lessons did not benefit global Ss more than analytic Ss.

The results of Study II were:

1. Ss studying expository lessons performed better than Ss studying discovery lessons.
2. This result was most evident on questions which assessed inference of the concept.
3. Expository lessons did not benefit impulsive Ss more than reflective Ss.

Chapter I

INTRODUCTION

History of the Problem

In the past few years the term "learning style" has appeared in the literature with great frequency. The general consensus seems to be that whatever "learning style" is, it should be taken into account when speaking of the reasons for a child's success or failure in the classroom. Unfortunately, that is where the consensus ends. Researchers have not agreed on what the term encompasses nor how to go about investigating it. Basically three approaches have been attempted.

The first approach views learning style as "different, identifiable ways in which students <u>approach</u> learning (Fischer & Fischer, 1968)." The logical way to investigate learning style defined in this manner is by actually observing how students go about learning. Fischer and Fischer (1968) compiled a list of eight learning styles by talking to competent teachers about their observations in the classroom. This was a start, but the naturalistic observations were not followed by validation studies nor by attempts to construct instruments to identify children demonstrating these styles.

A second approach defines learning style as an "attribute of an individual which interacts with instructional circumstances in such a way as to produce differential learning achievement as a

function of these circumstances (Tallmadge & Shearer, 1969, p. 222)." The research strategy accompanying this definition is based on the paradigm used for aptitude by treatment interaction (ATI) studies. Tallmadge and Shearer, for example, administered a large battery of tests measuring learner characteristics and determined which interacted with two instructional methods. They discovered a few learner characteristics which interacted with the instructional methods, but the implications of these results for instruction were not clear.

The third context in which the term "learning style" has appeared is individually guided instruction programs. Project PLAN defines learning style as "(a) need for teacher supervision: (b) need for social involvement: (c) need for media richness: (d) need for variety of learning activities: and (e) preferences for reading (Dunn, 1971, p. 3)." Project PLAN includes an individual's learning style among several variables such as interests and long-range goals which are used to select instructional units. However, to date, Project PLAN's attempts at matching instructional units with an individual's characteristics have been unsuccessful (Flanagan, personal communication).

A researcher (Nelson, in press) working with a second program of individualized instruction, the Individually Guided Education (IGE) program of the Wisconsin Research and Development Center for Cognitive Learning (WRDCCL) views learning style as one of four constellations of variables which affect a child's achievement in the classroom. The other three constellations of variables are (a) ability and achievement, (b) personality traits, and (c) motivation. Learning style is defined as an interaction between characteristics of individuals and instructional method.

The characteristics of individuals can be subsumed under one of two categories, (a) ways of acquiring and processing information and (b) preferences for certain aspects of instructional methods. The group of variables included under "ways of acquiring and processing information" consists of general cognitive style dimensions (e.g., field independence vs. vield dependence, leveling vs. sharpening, and reflectivity vs. impulsivity), as well as strategies employed in successfully completing a specific task (e.g., a focus gambling strategy in concept learning). The second group, "preference for certain instructional elements," includes variables such as preference for certain modes of information presentation, and preference for a certain amount of structure. See Nelson (in press) for a more complete presentation of the four conceptualizations of learning style.

Background of the Present Studies

The conceptualization of learning style advanced by the WRDCCL, in part, encompasses the three previous conceptualizations. Like the Fischers', it recognizes the importance of differences in learning processes. The Fischers speak of ways of approaching learning while Nelson speaks of ways of processing information. Both view the active participation in the learning situation as being an important element. The second group of variables proposed by the WRDCCL coincides with the variables investigated by Project PLAN. Where Project PLAN speaks of "needs" Nelson speaks of "preferences." And finally from Tallmadge and Shearers' conceptualization Nelson borrows the basic idea that a learning style is an interaction between organismic variables and elements in the instructional environment.

While the WRDCCL conceptualization coincides with others in terms of variables, it differs in terms of methodology. The methodology suggested by the WRDCCL is most similar to that used by Tallmadge and Shearer with some refinements. First of all, rather than using a large battery of organismic variables, organismic variables are selected by inferring which will interact with operations required by the task. Secondly, rather than arbitrarily selecting instructional methods, WRDCCL researchers design instructional methods which are inferred to be related to the organismic variables.

Using the WRDCCL conceptualization of learning style and the related methodology, the present studies attempt to identify two learning styles. The approach taken was to infer what organismic variables affect specific operations in concept learning, and to attempt to modify the effect of these variables on achievement by varying the instructional method used.

The operations involved in concept learning which were investigated are taken from Klausmeier's (1971) model of concept attainment. A brief summary of the cognitive operations postulated by this model will be given to show the rationale for selecting the organismic variables examined in the study. This, in turn will be followed by a definition of the instructional treatments which were compared.

Identification of the Operations to be Investigated

Klausmeier postulates that an individual can attain the same concept at four levels of mastery, concrete, identity, classificatory, and formal. These levels, which are successive, differ in their degrees of inclusiveness and abstractness. "Attainment of a concrete

concept is inferred when the individual cognizes an object that he has experienced on a prior occasion (p. 2)." Attainment of an identity concept is inferred "when the individual cognizes an object as the same one previously encountered when observed from a different perspective or sensed in a different modality, such as hearing or seeing (p. 2)." Attainment of "a rudimentary classificatory concept is inferred when the individual responds to at least two different instances of the same class as equivalent even though he cannot name the attributes common to them (p. 3)." And attainment of a "formal concept is inferred when the individual with normal language development can accurately designate certain objects or events as belonging to the same set and others as not belonging to the set, can give the name of the concept, and can name its intrinsic or societally accepted defining attributes (p. 3)."

The operations needed to reach a particular level differ. Each successive level includes the operations at the previous level plus one or more new operations. In order to attain a concrete concept an individual must have attended to an object, discriminated the object from other objects, and remembered the discriminated object. After attaining a concrete concept, if an individual has generalized that two or more forms of the same object are equivalent, he will have attained an identity concept of the object. The attainment of a classificatory concept involves the four operations involved in attaining an identity concept. In addition, the individual must generalize that two or more objects are equivalent in some way. The attainment of a formal concept involves the five prior

operations. In addition, the individual must discriminate the attributes of the concept and infer the concept either by testing hypotheses or by cognizing the common attributes in positive instances. After attaining a classificatory or formal concept, the individual is able to cognize relationships between it and other concepts and to use the concept in problem solving.

The two present studies investigate two individual difference variables which may affect the two operations which lead to the attainment of concepts at the formal level, discrimination of attributes and inference of the concept.

Study I

Selection of the Organismic Variable

If discrimination of attributes is important in attaining a formal concept, individuals who discriminate well should perform better on concept learning tasks than those who do not discriminate well. Analytic individuals "characteristically analyze and differentiate the stimulus field, applying labels to subelements of the whole," while individuals who are not analytic "tend to categorize a relatively undifferentiated stimulus (Kagan, Moss, & Sigel, 1963, p. 74)." Therefore, it could be expected that analytic individuals would be able to differentiate the attributes of a concept more easily than would non-analytic individuals. We would expect individuals who are analytic to perform better on a test of concept learning, especially on items which assess their ability to discriminate attributes, than individuals who are non-analytic.

Varying the Instructional Method

It is possible to vary the difficulty of concept acquisition by varying the difficulty of discriminating the attributes of that concept. Discrimination of attributes may be made more difficult by presenting positive and negative concept examples that are similar to one another. Discrimination of attributes may be made easier by emphasizing or drawing attention to the relevant attributes. Researchers (Frayer, 1970; Remstad, 1969) have found that emphasis generally facilitates concept learning. We expect that both analytic and non-analytic individuals would benefit from lessons which emphasize the relevant attributes. However, we would expect the non-analytic Ss would benefit more.

Methodology

High analytic and low analytic Ss were identified on the basis of their performance on the Hidden Figures Test (Educational Testing Service, 1962). All Ss studied the same geometry concepts presented in written lessons. Half of the high analytic and half of the low analytic Ss were randomly assigned to the emphasis condition, while the other half of each group were assigned to the no emphasis condition. The emphasis lesson was identical to the no emphasis lesson except for the inclusion of verbal emphasis of relevant attributes by statements and questions. The following hypotheses were investigated:

1. High analytic Ss will perform significantly better than low analytic Ss.

2. Ss who study the emphasis lessons will perform significantly better than Ss who study the no emphasis lessons.

3. The difference in performance between the emphasis and no emphasis lessons will be greater for the low analytic Ss than for the high analytic Ss.

Study II

Selection of the Organismic Variable

A second operation involved in acquiring a formal concept is inferring the concept. A concept can be inferred either by hypothesizing relevant attributes and evaluating these hypotheses using positive and negative instances or by cognizing the common attributes of positive instances. Both approaches involve the inference of the concept from subelements of the examples. This operation of inference is similar to the process of induction which involves arriving at a generalization or conclusion from bits of information. Kagan, Pearson, and Welch (1966a) found a relationship between scores on tests of inductive reasoning and scores on tests which measure reflectivity and impulsivity. Reflective children made fewer errors on the inductive reasoning tests than did impulsive children. Kagan *et al.* concluded that "Impulsive children make more errors in inductive reasoning problems because they do not pause to evaluate the quality of their inferences. The impulsive child responds quickly in situations where inferences are required; he seems to report the first reasonable idea that occurs to him (Kagan, Pearson, & Welch, 1966a, p. 594)."

If inductive reasoning or inference is important in attaining a formal concept, we would expect that reflective children would learn better than impulsive children when the task required that they discover the relevant attributes by deciding how the nonexamples differ from the examples or how the examples are alike. Reflective children would do better especially on test items which call for the knowledge of defining attributes or definition of the concepts after studying concept lessons than would impulsive children.

Varying the Instructional Method

We could minimize the need for inductive reasoning ability by eliminating the need to make inferences, i.e., by stating the relevant attributes. We should expect both the impulsive and reflective child to learn better from a lesson which provides the attributes for him (expository lesson) than from a lesson which requires him to discover or infer the attributes himself (discovery lesson). However, supplying the attributes would benefit the impulsive child more than the reflective child.

Methodology

Impulsive and reflective Ss were identified by using the Matching Familiar Figures Test, (Kagan, Rosman, Day, Albert, & Phillips, 1964). Half of the reflective and half of the impulsive Ss were presented a lesson written in an expository mode which explained why figures were or were not examples of the concept. The other half of the reflective and the other half of the impulsive Ss were presented a lesson written in the discovery mode which required S to compare figures and to decide how positive examples

were alike and how negative examples differed from positive examples. The following hypotheses were investigated:

1. Reflective Ss will perform significantly better than impulsive Ss.

2. Ss who study the expository lesson will perform significantly better than Ss who study the discovery lesson.

3. The difference in performance between the expository method and the discovery method will be greater for the impulsive Ss than for the reflective Ss.

Significance of the Studies

If the hypotheses in these studies are supported, two things will be accomplished. Two organismic variables which affect concept learning will be identified. The suggestion that they affect learning by interacting with operations in concept learning will remain plausible.

Secondly, this research suggests a method for investigating the effect of organismic variables on learning by varying the instructional method in such a way as to minimize the necessity of specific operations. This approach encourages the formulation of logical hypotheses about the effect of certain organismic variables on learning. These logical hypotheses, if supported, not only identify organismic variables, but also prescribe ways of dealing with individual differences by modifying the instructional method. Materials can be created to accommodate a child's approach to or style of learning.

Chapter II

PILOT STUDIES

Experiments were designed to ascertain whether interactions would occur between two organismic variables and specified instructional methods. One study investigated the relationship between an analytic or non-analytic cognitive style and concept learning as a result of studying a lesson in which there was either emphasis or no emphasis. A second study investigated the relationship between a reflective or impulsive cognitive style and concept learning as a result of studying a lesson which used either a discovery or expository approach.

Two pilot studies were carried out. Pilot Study I was run to evaluate the materials used in both studies and to determine if any revisions in the procedure were needed. A second purpose was to obtain an estimate of the time needed to complete the lessons and test. A second pilot study was conducted to assess the appropriateness of the standard form of the Matching Familiar Figures Test for seventh-grade students for use in Study II.

PILOT STUDY I

Subjects

The initial sample for this pilot study consisted of 61 Ss, from two classes in a junior high school in Mt. Horeb, Wisconsin. Seven Ss were lost due to absences, so that the results of the study

were based on 54 Ss. The two classes which participated in the study were heterogeneous with respect to general ability. A questionnaire (Appendix A) completed by the teacher of these students revealed that the students were unfamiliar with the concepts parallelogram, rhombus, and trapezoid.

Materials

Geometry Lesson I, Geometry Lesson II (emphasis), Geometry Lesson II (no emphasis), Geometry Lesson II (discovery), Geometry Lesson II (expository), and Test of Geometry Knowledge: Form PRT were used.

Geometry Lesson I: Geometry Lesson I provided background information necessary for understanding the geometry concepts by introducing the concepts line segment, closed figure, open figure, simple figure, non-simple figure, plane figure, solid figure, polygon, parallel, and quadrilateral. The format of this lesson required S to respond to questions regarding the concepts. Immediate feedback was provided for these questions.

Geometry Lesson II: Seven examples, four positive and three negative in the sequence +,-,+,-,+,-,+ were given for each of the three concepts, parallelogram, rhombus, and trapezoid. Parallelogram was presented first, followed by rhombus and trapezoid. The concepts were presented in this manner and sequence, using the same figures in all four methods of presentation: emphasis, no emphasis, discovery, and expository.

The difference between the emphasis and no emphasis lessons occurred in the inclusion of prompting statements and questions in the emphasis condition. In the emphasis condition, S was told to pay special attention to the attribute which defined a particular concept. The figures were labeled as positive or negative examples. Following the presentation of each figure, questions which drew attention to the relevant attributes were asked. No feedback was provided for these questions. In the no emphasis condition, the students were not alerted to the relevant attributes by statements and questions. The figures were labeled as positive and negative examples. Table 1 will clarify the differences between the emphasis and no emphasis conditions. Appendix C contains the actual lessons.

The difference between the discovery and expository lessons occurred in the presence or absence of a definition and in the inclusion or non-inclusion of statements and questions. In the discovery method no definition was presented. The students were told to notice how figures were alike and how they were different. The figures were labeled as examples or non-examples. Questions following presentation of the figures asked students to tell how positive examples were alike or how positive examples differed from negative examples. After presentation of the seven figures, S was asked to tell how the four positive examples were alike. No feedback was provided for any of the questions. In the expository method of presentation, a definition of the concept was followed by examples which were labeled as positive or negative. Statements indicating why a figure was or was not an example of the concept followed each

figure. Table 1 will clarify the differences between the discovery and expository methods of presentation. Appendix C contains the actual lessons.

Test of Geometry Knowledge: Form PRT. A nine-question test using a true false format was used. Each question required Ss to respond to several individual items e.g. the instruction "If the figure is a parallelogram circle yes. If it isn't circle no," was followed by twelve figures. Each of the three concepts had one question which required knowledge of defining attributes (Type I), one which required recognition of examples (Type II), and one which required knowledge of the definition (Type III). Types I and II had 12 items each while Type III had 18 items for each of the three concepts. Therefore, there was a total of 126 separate items in the test. The test is presented in Appendix D.

Procedure

Ss were stratified on the basis of IQ as measured by the California Test of Mental Maturity, and then were randomly assigned to one of the four treatment conditions, emphasis, no emphasis, discovery, or expository. All Ss received an introductory lesson, Geometry Lesson I, on the first day. On the second day, those Ss assigned to the emphasis group were given Geometry Lesson II written in the emphasis mode and Test of Geometry Knowledge: Form PRT; those Ss in the no emphasis group were given Geometry Lesson II written in the no emphasis mode and the test; those Ss in the discovery group were given Geometry Lesson II written in the discovery mode and the test; those Ss in the expository group were given Geometry Lesson II written in the expository mode and the test.

Table 1

A Comparison of the Four Types of Instructional Methods

Discovery	Expository	Emphasis	No Emphasis
General instructions. Instructions to note how figures are alike and different.	General instructions.	General instructions. Instructions directing attention to relevant attributes.	General instructions.
	Definition of the concept.		
Four examples and three non-examples in the sequence +,-,+,-, +,-,+. The figures are labeled as examples or non-examples.	Four examples and three non-examples in the sequence +,-,+,-, +,-,+. The figures are labeled as examples or non-examples.	Four examples and three non-examples in the sequence +,-,+,-, +,-,+. The figures are labeled as examples or non-examples.	Four examples and three non-examples in the sequence +,-,+,-, +,-,+. The figures are labeled as examples or non-examples.
Question after each figure asking for comparison between figures. No feedback.	Explanation after each figure of why the figure is or is not an example of the concept.	Question after each figure drawing attention to the relevant attributes of the figure. No feedback.	
A question asking how the four positive examples are alike. No feedback.			

Design

Each lesson dichotomy, emphasis versus no emphasis and discovery versus expository was analyzed separately. The design for each was a 2 x 3 factorial with two lesson types (emphasis and no emphasis or discovery and expository) and three levels of general ability (high, medium, and low).

Results

Two dependent variables were obtained for each S, his total score on the Test of Geometry Knowledge and an estimate of IQ assessed by the California Test of Mental Maturity.

Table 2 presents the observed means and standard deviations of scores on the Test of Geometry Knowledge and number of Ss who studied the emphasis and no emphasis lessons.

Table 2

Observed Mean Total Scores and Standard Deviations on the Test of Geometry Knowledge and Number of Ss for the Emphasis and No Emphasis Groups by IQ Level

		Treatment	
		Emphasis	No Emphasis
	High	101.75 (7.14) N = 4	100.20 (6.91) N = 5
IQ Level	Medium	90.60 (6.47) N = 5	92.40 (9.48) N = 5
	Low	81.50 (10.85) N = 4	90.75 (12.26) N = 4

Note.--Standard deviations are given in parentheses.

An analysis of variance (Table 3) was performed on the data presented in Table 2. The difference between the emphasis and no emphasis groups was not significant, but there was a significant IQ effect. There was no treatment by IQ interaction.

Table 3

Analysis of Variance of Total Scores on the Test of Geometry Knowledge for the Emphasis and No Emphasis Groups in Pilot Study I

Source	df	MS	F	p<
Treatment	1	81.80	1.03	.32
IQ	2	467.89	5.87	.0095*
Treatment x IQ	2	63.84	.80	.46
Between Subjects within Cells (Error)	21	79.70		

*Significant at or beyond the .05 level chosen.

Table 4 presents the observed means and standard deviations of scores on the Test of Geometry Knowledge and number of subjects in the discovery and expository groups.

An analysis of variance (Table 5) was performed on these means. The results of this analysis were similar to those for the emphasis and no emphasis comparison. There was no significant treatment effect nor treatment by IQ interaction, but there was a significant IQ effect.

During the administration of the lessons and test there were no indications that Ss had difficulty understanding what the lessons required of them. However, on the test there were a few items which caused

Table 4

Observed Mean Total Scores and Standard Deviations on the Test of Geometry Knowledge and Number of Ss for the Discovery and Expository Groups by IQ Level

		Treatment	
		Discovery	Expository
IQ Level	High	99.33 (4.73) N = 3	107.40 (5.30) N = 5
	Medium	96.80 (6.30) N = 5	93.60 (11.67) N = 5
	Low	91.25 (9.46) N = 4	91.80 (13.22) N = 5

Note.--Standard deviations are given in parentheses.

Table 5

Analysis of Variance of Total Scores on the Test of Geometry Knowledge for the Discovery and Expository Groups in Pilot Study I

Source	df	MS	F	p<
Treatment	1	27.11	.31	.58
IQ	2	357.69	4.13	.03*
Treatment x IQ	2	68.86	.80	.46
Between Subjects within Cells (Error)	21	86.54		

*Significant at or beyond the .05 level chosen.

some confusion because of poor printing quality. These items were corrected prior to the main studies.

The pilot study was run to not only evaluate the materials but to also evaluate the procedure and obtain an estimate of the time required to

complete the materials. The procedure appeared to be satisfactory for this type of task. The instructions were understood and followed by most Ss. All Ss completed the introductory lesson on Day 1 well before the class period ended. All but one S finished the lesson and test sequence on Day 2. It was decided that the materials would not have to be shortened or in any way revised before being used in the main studies.

Discussion

It was expected that there would be a significant difference between emphasis and no emphasis lessons and between discovery and expository lessons. Other than the small number of subjects in each cell, no explanations for this lack of differences can be made. Based on the significant differences found by others who used similar treatment conditions, it was decided to retain the treatment methods as defined. No changes in procedure or in the length of the instructional materials were deemed necessary.

PILOT STUDY II

Pilot Study II assessed the appropriateness of using the standard form of the Matching Familiar Figures Test (MFF) for seventh-grade students. This was thought advisable since most research using the standard form of the MFF had involved Ss below the fourth-grade level. The pilot study was run to estimate the amount of time required to run each subject and to determine whether there was adequate dispersion of error and latency scores.

Subjects

Nine seventh graders were randomly selected from a Mt. Horeb math class not involved in Pilot Study I. The mathematics teacher estimated that two Ss represented low general ability, two represented high general ability, and five fell within the average range of general ability.

Materials

The Matching Familiar Figures Test (MFF) which measures reflection over alternative solutions was used to discriminate between reflective and impulsive students. This test consists of twelve items plus two practice items. Each item consists of two sheets, one of which has a picture of one object and the other has an array of six objects, one of which is identical to the target object and five of which resemble the target object but differ in various detailed ways. S is asked to choose the object from the array which is identical to the target object. He is allowed to choose objects until he selects the correct one. Two scores are obtained, latency to first response and number of incorrect choices. A reflective child is defined as one who is above the median in total latency to first choice over the twelve items and below the median number of errors for total errors over the twelve items. An impulsive child is defined as one who scores below the median in latency and above the median in errors. (Kagan, et al., 1964.)

Procedure

The MFF was individually administered to each S according to the directions.

Results

No statistical analysis was performed on the data from Pilot Study II. On the basis of the results it was decided that the test would be appropriate for seventh-grade students. The time needed to administer the test was approximately ten minutes. The number of errors ranged from 2 to 11 with a median of 5 and the latencies ranged from 74 to 211 1/2 seconds with a median of 130 1/2 seconds. Of the nine Ss, two met the dual criterion for reflectivity, two met the criterion for impulsivity, two fell on the median and were not classified, and four were either above median errors and above median time or were below median errors and below median time.

Chapter III

REVIEW OF RELEVANT LITERATURE, METHODOLOGY, AND RESULTS FOR STUDY I

The purpose of Study I was to examine the effects of the analytic-non-analytic cognitive style on the immediate acquisition of selected geometry concepts presented under one of two treatment conditions, verbal emphasis or no emphasis.

Review of Relevant Literature

Organismic Variable--Analytic versus Non-analytic Cognitive Style

The distinction between analytic and global (non-analytic) or field independent and field dependent cognitive styles has been expressed differently by researchers. Witkin, Dyk, Faterson, Goodenough and Karp (1962) state that:

> The person with a more field-independent way of perceiving tends to experience his surroundings analytically, with objects experienced as discrete from their backgrounds. The person with a more field-dependent way of perceiving tends to experience his surroundings in a relatively global fashion, passively conforming to the influence of the prevailing field or context (p. 35).

Goodenough and Eagle (1963) define field-independent "as the ability to overcome an embedding context in perception (p. 67)." And finally Kagan et al. (1963) see analytic Ss as those who prefer a mode of categorization based on physical attributes, while global Ss are those who prefer a mode of categorization based on functional relationships.

These three different ways of distinguishing between field dependent and field independent subjects reflect variations in the way this cognitive style dimension has been assessed. The task consistent with Witkin et al.'s definition involves the orientation of an object or body in space. The task consistent with Goodenough and Eagles' definition involves finding a simple figure in a complex design. And finally, the task consistent with the definition suggested by Kagan et al. involves categorizing pictures of people or objects on the basis of some commonality.

Orienting an Object in Space

Several tasks have been devised to measure a person's ability to orient his body or an object to an upright position under various types of visual or postural distortion. The Tilted Mirror (Asch & Witkin, 1948a) which was later changed to the Tilted Room (Asch & Witkin, 1948b) and the Tilting-Room-Tilting-Chair (Witkin, 1949) tasks evaluate the individual's perception of the position of his body and of the surrounding field in relation to the upright. In the Tilting-Room-Tilting-Chair task, S is seated in a chair in a small room. The chair and room can be tilted in the same direction or in opposite directions. S's task is to either adjust the room to the upright position while his chair remains tilted (Room Adjustment Test--RAT) or to adjust his chair to the upright while the room remains tilted (Body Adjustment Test--BAT). The Rotating Room Test (Witkin, 1949) evaluates the subject's perception of the position of his body and of his surroundings when the direction of the force acting on his body has been changed. S is seated in an upright chair

within an upright room which is driven about a circular track. S is requested to adjust the chair or the room to the upright position if he feels it is necessary.

The most widely used orienting an object type task is the Rod and Frame Test (Witkin, Lewis, Hertzman, Machover, Meissner, & Wapner, 1954). This task, which evaluates the individual's perception of the position of an item in a field, requires S to adjust a luminous rod mounted within a luminous square frame to the gravitational vertical.

Most of the research with these tasks has involved establishing reliability and validity estimates and investigating developmental trends and sex differences. It appears that the trait measured by these tasks is relatively stable over time. Witkin (1949) reported correlations of .85 for males and .86 for females for the tilting room, and .88 for males and .87 for females for the RFT over a period of one year. The stability of a field independent disposition has also been established for longer periods of time. Witkin, Goodenough and Karp (1967) found that scores on the Rod and Frame and Tilting-Room-Tilting-Chair tests increase with age but they also found that the relative position of an individual within a group remained stable over a period of about seven years. Most correlations among tasks indicate that they are valid in the sense of measuring the same trait as well as reliable (Busch & Simon, 1972).

There appears to be a developmental trend in the field independent-field dependent dimension as measured by these tasks. Older children are more accurate than younger children (Busch & Simon, 1972). However, the increase in performance is not uniform across age levels. Witkin

(1949) studying 8-, 10-, and 13-year-old Ss found the greatest increase between the 10 and 13 year olds. Witkin, Goodenough, and Karp (1967) report some data which suggests that the rate of change from dependence to independence may decrease with increasing age and may cease during the later teen years. There is also some evidence that there is a return to a more field dependent state later in life. They concluded that the "development of psychological differentiation tends to approach a plateau in young adulthood (p. 298)."

Witkin (1967, 1969) found a relationship between sex and scores on the Rod and Frame Test and Tilting-Room-Tilting-Chair. In longitudinal and cross sectional studies he found that males between the ages of about 8-17 were more field independent than females and that adult women tended to go along with the visual field more and to respond less to bodily experiences than men. Busch and Simon (1972) failed to find a difference in the performance of 5-7 year olds on the Rod and Frame test. This suggests that the difference between the performance of males and females may occur after the age of seven.

Locating a Simple Figure in a Complex Pattern

The second type of task used to assess the analytic-global cognitive style involves finding a simple figure in a more complex design. S is presented a target item, e.g., a simple line drawing of a polygon or an outline of a simple object. He is then presented a complex figure in which the simpler figure is embedded. S must locate the simple figure in the complex design.

Although the task is the same among the various instruments available, the number of variations imposed on this task has created a large number of separate instruments. Most of these tasks use geometric figures as stimuli but some, e.g., the Children's Embedded Figures Test (CEFT) (Goodenough & Eagle, 1963) and the Hidden Figures Test (HFT) (Kagan, et al., 1964) use meaningful stimuli. Some use colored figures, e.g., Witkin's (1950) Embedded Figures Test (EFT) and the CEFT, but most use black-and-white line drawings. Most of the early tests were individually administered but later, group forms became available (Jackson, Messick, & Myers, 1964). Some forms require memory, e.g., Witkin's EFT, while others do not require memory, e.g., the Hidden Figures Test (Educational Testing Service, 1962).

Of the many tests available, three have been used most extensively in research: a shortened form of Witkin's original EFT (Jackson, 1956), the Children's Embedded Figures Test (CEFT) created by Karp and Konstadt (1963), and the Hidden Figures Test (HFT) published by the Educational Testing Service (1962).

The shortened form of Witkin's EFT is comprised of 12 items. Each item consists of a colored complex figure and a simple black-and-white figure. A complex figure is presented to S for 15 seconds and then removed. Then the simple figure is presented for 10 seconds and removed. The complex figure is presented again and S is asked to trace the simple figure in the complex design. S is allowed to look back at the simple figure whenever he wishes, but the complex figure is always removed before the simple figure is presented. His score is the amount of time taken to locate all 12 simple figures.

The Children's Embedded Figures Test is a simplified version of the EFT. However, meaningful figures are used instead of geometric designs. The score is the number of simple figures correctly identified. The testing is terminated if S fails a specified number of items.

The Hidden Figures Test is a group-administered test composed of two 16-item parts. Ss are required to tell which of five simple figures is embedded in each of the 32 complex, black-and-white geometric designs. Memory is not involved, but guessing is possible. For this reason, the score is corrected for guessing. The score is the number correctly found minus 1/4 the number incorrectly identified within a ten-minute period.

The embedded figures type tasks appear to measure the same thing as the orienting an object type tasks. Witkin (1949) found significant correlations between the EFT and the Tilting-Room Test for males and females, between the EFT and the Rod and Frame Test for males and between the EFT and the Rotating-Room Test for males and females. Young (1959) also found a relationship between the Rod and Frame Test and the EFT. Goodenough and Karp (1961) found that the CEFT, Rod and Frame Test and Body-Adjustment test loaded on the same factors, which they identified as a perceptual field dependence factor. Karp (1963) also identified this same factor using the EFT, Rod and Frame Test and Body-Adjustment Test.

Reliability estimates are generally encouraging. Dana and Goocher (1959) reported significant Pearson product moment correlations between two administrations of the shortened form of the EFT over a one-week period. Witkin (1950) reported odd-even coefficients of .87 for males

and .74 for females on the EFT. And finally, Goodenough and Eagle (1963) reported that KR_{20} reliability estimates for children 6, 7, 8, and 9 years of age ranged from .62 to .82. There was a trend toward increased reliability with age, and boys tended to have higher coefficients than girls.

Results from studies of these tests suggest that ability to overcome embedding context increases with age (Goodenough & Eagle, 1963) and differs for older males and females. Corah (1965) found no significant difference between the performance of boys and girls ranging in age from 8 to 11 years on the CEFT and Goodenough and Eagle (1963) found no sex differences between 5 and 8 year olds on the CEFT. Fredrick (1968) found no difference between sixth-, eighth-, or tenth-grade males and females on the HFT. However, Corah (1965) and Witkin (1950) found that men took significantly less time than women in locating the figures on the EFT. Sex differences appear during adulthood rather than during childhood.

Much of the research involving hidden figures tests has focused upon finding correlates of the analytic cognitive style. Research relating scores on an embedded figures test to performance on learning tasks and to situations involving some type of social interaction has generally been more fruitful than studies which investigate the relationship between personality traits and performance on embedded figures tests.

The studies relating the analytic-global cognitive style to learning will be discussed more completely later. Basically these studies demonstrate that analytic Ss perform better on concept learning tasks than global Ss (Davis, 1967; Elkind, Koegler, & Go, 1963; Fredrick, 1968;

Ohnmacht, 1966). Attempts to modify the learning tasks to facilitate learning by global Ss have been largely unsuccessful (Davis, 1967, 1972).

Research on the relationship between social situations and analytic-global cognitive styles has revealed some interesting differences between global and analytic Ss. It appears that field-dependent Ss are more sensitive to social factors than field-independent Ss. Konstadt and Forman (1965) found that social disapproval in a learning situation hindered field-dependent Ss more than field-independent Ss. Messick and Damarin (1964) found that field-dependent Ss were able to recognize faces they had seen before better than field-independent Ss. And finally, Fitzgibbons, Goldberger, and Eagle (1965) found that field-dependent Ss were more able to recall incidentally learned words which had social implications than field-independent Ss.

It appears that field-independent Ss are superior to field-dependent Ss in situations requiring the acquisition of concepts, but that field-dependent persons are more sensitive to social cues. There is no such generalization which can be made concerning personality traits and the tendency to be field-independent or dependent. Dana and Goocher (1959) administered a battery of tests including the shortened form of the EFT, the Edwards Personal Preference Scale and the TAT to men and women. Out of a total of 95 correlations only 3 were significant. Since the probability of obtaining 3 significant correlations out of 95 is not appreciably above chance expectation, no definite conclusions can be drawn from this study.

Categorizing Objects

The third type of task used to assess the analytic-global cognitive style was developed by Kagan, Moss, and Sigel (1963). This task consists of choosing figures from an array which go together and stating the reason for the categorization. Responses are classified as analytic-descriptive, relational, or inferential-categorical. The analytic-descriptive category includes responses which reveal categorizations based on similar objective elements which are part of the complex stimuli. The relational category includes responses based on functional relationships between the stimuli. The inferential-categorical category includes responses based on some inferred quality which the chosen stimuli share. The analytic-descriptive response requires the greatest amount of analysis, while the relational response requires the least amount of analysis. Analytic and non-analytic Ss are defined using one of two criteria, median responses or proportion of responses, e.g., Ss above the median in analytic-descriptive and below the median in relational and inferential-categorical responses are analytic, while those above the median in relational responses and below the median in the other two are global--or Ss who have 2/3 of their responses classified as descriptive are analytic, while those who have 2/3 of their responses classified as relational are global.

Three tests based on this task have been used most frequently in research, a figure sorting task (Kagan, et al., 1963), the Conceptual Style Test (CST) (Kagan, et al., 1963), and Sigel's Cognitive Style Test (1967). The figure sorting task, which is for adults, consists of three arrays of approximately 22 pictures of people in each array. S is shown an array and asked to select figures that go together on a common basis.

A total of 32 conceptual responses is obtained from the three arrays. Each response is scored as belonging to one of two orientations (ego-centric or stimulus centered) and one of three conceptual classes (analytic-descriptive, relational, or inferential-categorical).

The Conceptual Style Test (CST) consists of 30 triads of black-and-white drawings. For each triad, the child is asked to select two pictures that go together in some way. For all triads, two and sometimes all three response types are possible. However, the pictures are rather simple and thus do not allow for highly inferential concepts. Thus this test is used mainly to study analytic-descriptive and relational responses. This test is for children.

The Sigel Cognitive Style Test (SCST) is similar to the CST. Two forms are available, one for girls and one for boys. Responses are classified as relational-contextual, categorical-inferential, descriptive part-whole, or descriptive global. The first three response classifications are similar to those proposed by Kagan, et al. (1963). The descriptive-global classification involves "similarities based on the total objective manifestations of the stimuli (Sigel, Jarman, & Hanesian, 1963, p. 8)."

Other than the studies summarized by Kagan, et al. (1963) and Sigel (1963) not many have attempted to establish stability estimates, sex differences, or age trends. Kagan, et al. (1963) reported stability estimates for third graders tested with the CST and retested after one year. Analytic responses showed high stability for girls (.70) and moderate stability for boys (.43). The coefficients for non-analytic

relational responses were .64 for girls and .40 for boys. Stability of an analytic conceptual style was .73 for boys tested in fourth and retested in fifth grade and .47 for boys tested in grades one or two and retested in grades two or three. A split-half reliability estimate for the CST based on 300 protocols was .94. For 46 sixth graders the odd-even reliability estimate for analytic responses was .91; for relational responses .90; and for inferential responses .74.

Sigel (1963) reported stability coefficients on a sorting task for children similar to the sorting task for adults. In this task, children select pictures of humans (HST) or pictures of objects and animals (OAST) from an array on the basis of some relationship. Children in grades two and three were tested and retested annually for three years. Sigel found that classifications were moderately consistent from year to year but not over a two-year period. Stability was greatest for descriptive part-whole classifications.

No estimates of correlations among the various categorizing tasks have been reported. Kagan, _et al_. (1964) reported a moderate correlation ($p < .10$) between the number of analytic responses on the CST and performance on the Hidden Figures Test.

There appears to be age trends evidenced in performance on these categorizing tasks. Kagan, _et al_. (1963) found that there is a linear increase in analytic responses with increasing age. Relational responses decrease with increasing age. These trends were also reported by Sigel, _et al_. (1963).

Differences between the performance of boys and girls on the CST have been reported by Kagan, et al. (1963). The analytic and inferential responses of sixth-grade boys were negatively correlated with relational responses. Analytic-descriptive and inferential responses were independent of each other. For girls, analytic and inferential responses were each inversely related to relational responses, and analytic and inferential responses were negatively correlated. Frehner (1972) reported that sixth-grade girls demonstrated a descriptive-global cognitive style, while boys demonstrated a relational-contextual cognitive style on the SCST.

There is a consistent finding that the preference for analytic responses is correlated with performance IQs but not related to verbal IQs. Kagan, et al. (1964) reported a significant relationship between the Picture Arrangement Subtest of the WISC and analytic responses, but no relationship with verbal subtests was found. Kagan, et al. (1963) reported a significant relationship between descriptive part-whole responses and the performance IQ of the California Mental Maturity Scale for boys and a negative relationship between relational-contextual responses and both verbal and performance IQs.

Most of the research involving these tasks has focused on finding correlates of the analytic-global preference. Kagan, et al. (1963, Study E) reported that analytic children are more likely to give responses containing reference to parts of the percepts on ink blot tests and to mention objective parts before themes on TAT pictures. In another study (Study A) they found that "analytic-descriptive men were ambitious, independent, and had relatively high levels of spontaneous sudomotor

reactivity. Men who preferred relational concepts were dependent, not overly ambitious, and showed less labile sudomotor reaction (p. 78)."

In addition to correlational studies identifying variables related to the analytic-global cognitive style as defined by categorizing tasks, a group of studies have dealt with the effects of an analytic preference on performance under different instructional methods or training procedures.

Coop and Brown (1970) looked at the differential effects of a teacher-structured method and an independent-problem-solving method of instruction on achievement by analytic and non-analytic undergraduates identified by their performance on the SCST. The teacher-structured approach consisted of a combination of lectures and discussions. The independent-problem-solving approach involved independent work, the presentation of film strips, and group discussions.

Coop and Brown found no significant interaction between cognitive style and teaching method on their test which assessed attainment of factual content and conceptual generalizations. Regardless of cognitive style, Ss performed significantly better under the teacher-structured method than under the independent-problem-solving method.

Unlike Coop and Brown, Scott (1972) did find a relationship between method of instruction and cognitive style. He administered the SCST to high school students who had been exposed to the Inquiry Strategy in later elementary or early junior high school science classes and to high school students who had received conventional science training. Under the Inquiry Strategy the students are required to solve a problem presented in a demonstration by processing information which they gain by

asking "yes" and "no" questions of the teacher. Scott found that Ss who had experienced the Inquiry Strategy made significantly more descriptive part-whole responses than Ss receiving conventional science teaching.

Yeatts and Strag (1971) hypothesized that it was not S's preference for analytic responses which makes his academic performance superior, but rather it is his ability to shift his preferences among the types of responses. Fourth- and sixth-grade students were administered the CST. Ss were encouraged to make as many categorizations as possible during 45 seconds. S's first response indicated his preferred response. A flexibility score indicated the number of times S changed his preference. A fluency score indicated the total number of responses to all items. Ss were then classified as "below," "at," or "above" grade level on mathematic and verbal ability subtests of the California Achievement Test.

They found that Ss who changed their cognitive style preference, i.e., were flexible, performed above grade level on both mathematics and verbal subtests. Those who were inflexible tended to be below grade level on these subtests. A multiple correlation between fluency, flexibility, mathematics, and verbal scores suggested that students who were more fluent do better on verbal tests, while those who are more flexible do better on mathematics tests.

Baird and Bee (1969) attempted to modify the responses given on CST-like items through differential reinforcement. Analytic and non-analytic first and second graders were defined on the basis of their performance on the CST and randomly assigned to either an analytic or

non-analytic training group or control. Each S was then presented 26 CST-like training items. Ss in the analytic condition were rewarded for making analytic responses, while Ss in the non-analytic condition were rewarded for making non-analytic responses. Control Ss were randomly rewarded with the chips which could be exchanged for M & Ms. After training all Ss received a posttest.

Baird and Bee found that analytic training produced increases in analytic responses for both analytic and non-analytic Ss. Random reward resulted in a significant increase in analytic responding for analytic Ss. Non-analytic training did not produce a significant decrease in analytic responding by either analytic or non-analytic Ss.

Beller (1967) hypothesized that matching the method of language training to a child's cognitive style would be more effective than training a child with a method not related to his cognitive style. He identified analytic and non-analytic nursery school children using the SCST and randomly assigned them to an analytic, non-analytic, or control training group. During the training session Ss were shown pairs of objects and were taught the correct labels. Then E formulated a descriptive-analytic association between the two objects for Ss in the analytic training group and a contextual-relational association for Ss in the non-analytic training group. Control Ss received no training.

Both recognition memory and association memory were used as dependent variables. A paired associate task in which one of the two objects was presented and S was required to name the second object was the measure of recognition memory. Association memory was assessed by asking S why the two objects had been presented together. Beller found that children

trained with the descriptive-analytic procedure received highest scores on recognition memory, while children trained with the contextual-relational procedure received highest scores on association memory. The effectiveness of matching cognitive style and training method was supported by consistent but nonsignificant trends.

Differences between pre- and posttest results on selected subtests of the Illinois Test of Psycholinguistic Ability showed that analytic children made higher scores than non-analytic. Children with poor pretest scores benefited most from contextual-relational training. Descriptive-analytic Ss gained most under the descriptive-analytic method and showed a negative change when trained under the contextual-relational method. Children with a contextual-relational style showed a negative change when trained with the descriptive-analytic method.

Analytic-Global Cognitive Style and Concept Learning

Because of the variables investigated or the methodology employed, several studies are especially relevant to the present study. Five studies have dealt with the effects of an analytic or global preference on concept attainment, and two studies have attempted to modify instructional treatment to accommodate a global cognitive style. Two of the four studies assessing the effect of cognitive style on concept learning used correlational techniques (Elkind, Koegler, & Go, 1963; Fredrick, 1968), while three compared performance of analytic and global Ss on a concept learning task (Davis, 1967; Lee, Kagan, & Rabson, 1963; Ohnmacht, 1966).

Elkind, Koegler, and Go (1963) hypothesized that field-independent Ss would receive significantly higher scores than field-dependent Ss on

a test that required formation of a concept defined by perceptible commonalities. They identified field-dependent and independent adults by administering the shortened form of the EFT. The Abstraction Test of the Shipley Hartford Scale (SHA) which is a test of perceptual concept formation and the Shipley Hartford Vocabulary Test (SHV) were administered to all Ss.

Elkind, Koegler, and Go found that field-independent Ss obtained significantly higher scores than field-dependent Ss on the SHA for males, females, and for all Ss. There was no difference between field-independent and field-dependent Ss on the SHV. This study demonstrated that the preference for an analytic or non-analytic cognitive style is related to a perceptual concept learning task but not related to a highly verbal task.

Fredrick (1968) administered the HFT, the Tagatz Information Processing Test (TIPT) (Tagatz, Lemke, & Meinke, 1969) and a concept learning problem (CLP) to sixth, eighth, and tenth graders. Each of the 30 items on the TIPT consists of a focus card made up of six bi-valued dimensions and two other cards also made up of the same six dimensions but containing a different combination of the twelve possible values than the focus card. One of these two cards is marked "yes" or "no" and the other card is marked with a question mark. S is required to process the information provided by the focus and "yes" and "no" cards to determine whether the card with the question mark is a "yes" card, "no" card, or a "can't tell" card (indicating insufficient information). S is provided feedback.

The CLP (developed by Fredrick) consists of two stories from which S can learn the relevant attributes of (a) plants which would be good to eat and (b) animals which would bite. The plants consist of four bi-valued dimensions, two of which are relevant, and the animals consist of seven bi-valued dimensions, two of which are relevant. The animal problem, therefore, contains more irrelevant information than the plant problem. On the basis of information provided by the stories, S is required to categorize new instances of plants and animals. The dependent measures are instances correctly categorized, inclusion errors, and exclusion errors.

Fredrick found that Ss who scored low on the HFT made significantly more errors than Ss who scored high on the HFT in classifying cards into "yes" and "no" categories on the TIPT. This was a result of their tendency to place cards which could be classified as "yes" or "no" into the "can't tell" category.

Ss who scored low on the HFT made more inclusion errors on both problems of the CLP and more exclusion errors on the CLP problem with the most irrelevant information than did those who scored high on the HFT. Fredrick concluded that the analytic Ss have developed an ability to make inclusion decisions more accurately than global Ss. They also make decisions concerning exclusion better than global Ss when the number of irrelevant dimensions is high.

It appears that analytic Ss do better on tests which assess concept learning than global Ss. Lee, Kagan, and Rabson (1963) investigated the effects of preference for analytic categorization upon concept acquisition

using a paired associate learning task, while Ohnmacht (1966) investigated this relationship using a concept learning shift problem.

Lee, Kagan, and Rabson were interested in determining whether the preference for analytic categorization differentially affected the rate at which different types of concepts were attained. Third grade boys, representing extremes on the CST, were required to learn six concepts. Two of these concepts were analytic, i.e., the basis of classification involved an attribute which had to be differentiated from the total stimulus; two were relational, i.e., the basis of classification was a functional relationship; and two were inferential-categorical, i.e., the basis of classification was some inferred common quality or language convention. The task consisted of learning to pair a nonsense syllable with pictures which represented these types of concepts. S's score was the number of trials needed to correctly label 18 consecutive pictures.

The learning scores for each pair of same type concepts were combined for the analysis. The main effects of cognitive style and type of concept were not significant. However, a significant interaction between conceptual preference and type of concept provided evidence that analytic boys learned analytic concepts faster than did non-analytic boys.

Ohnmacht (1966) used a traditional concept learning paradigm in assessing the effect of an analytic preference on the ease with which a reversal or non-reversal shift is learned. Analytic and non-analytic men were identified by the EFT and were presented a card sorting concept learning task. Upon reaching the criterion of 15 correct sorts, half of the analytic and half of the non-analytic Ss were presented a reversal shift problem

which required them to sort on the basis of different values along the same relevant dimensions. The other half of each group was presented a non-reversal shift problem which required S to sort on the basis of entirely new relevant dimensions. Scores were the number of trials needed to reach the criterion of 15 correct sorts on the second problem. Ohnmacht's prediction that analytic Ss would accomplish both shifts more easily than non-analytic Ss was supported by the data.

Fredrick (1968) found that differences between analytic and non-analytic Ss on concept learning were most pronounced on problems with the most irrelevant information. A study by Davis (1967, Study 1) was addressed more directly to the question of the effect of complexity. Davis selected high school males representing high, moderate, and low scores on the HFT. These Ss were presented a concept attainment task which required them to correctly sort concept stimuli into four categories representing combinations of two values of each of two relevant dimensions. Complexity was manipulated by varying the number of irrelevant dimensions. The least complex condition had instances with one irrelevant dimension, the moderate complexity condition had three irrelevant dimensions, and the most complex condition had five irrelevant dimensions.

Main effects of cognitive style and complexity were significant. High analytic Ss made fewer errors than middle analytic Ss who made fewer errors than low analytic Ss; high complexity led to more errors, low complexity to fewer errors. The hypothesized interaction between cognitive style and complexity, however, was not found.

Based on the studies cited, it appears that with the exception of

social sensitivity, analytic Ss are superior to non-analytic Ss on just about every variable which has been investigated. Hypotheses have been offered to account for this superiority, but few of the hypotheses have been empirically tested. An experimental strategy used by Davis (1967, 1972) and employed in the present study sheds light on the reasons for the superiority of analytic Ss on certain tasks. The strategy consists of changing the conditions of learning to minimize the need for the ability which the global Ss are thought to lack, or to compensate for this deficiency through training.

Davis (1967, Study 2) sought to determine whether the deficit in low analytic Ss could be overcome by one or a combination of training procedures, verbalization and prompting. Analytic and non-analytic males were selected on the basis of their performance on the HFT, and randomly assigned to one of four conditions, (a) verbalization, (b) prompt, (c) prompt and verbalization, and (d) control. Davis presented the same types of problems in Study 2 as he did in Study 1. Ss in the prompt condition, however, were shown the correct answer before responding. Ss in the verbalization condition were required to describe all of the values present in each of the stimulus patterns before responding. The prompt-verbalization condition was a combination of the two conditions.

Davis found that high analytic Ss committed fewer errors than low analytic Ss. The verbalization and prompt groups were superior to the control, but the combination was not. The cognitive style by treatment interaction was not significant. The global Ss did not appear to benefit from the training procedures.

A later study by Davis (1972) also attempted to affect the concept attainment of global and analytic Ss, identified by the HFT, by varying treatment. He predicted that analytic Ss would perform better on a task requiring attention to subelements of a stimuli, but that global Ss would perform better on a task requiring attention to the whole stimulus. The task employed was a transverse patterning discrimination problem. Under a non-sign-differentiated condition, correct responding was dependent upon a conditional relationship among figures rather than subelements of stimuli. Under the sign-differentiated condition, correct responding could be achieved by attending either to the subelements of the stimuli or to a relationship between stimuli.

Davis' hypothesis was that analytic Ss would perform better on the sign-differentiated problem, but that non-analytic Ss would perform better on the non-sign-differentiated problem. The hypothesis was supported in part. Analytic Ss performed better than non-analytic Ss on the sign-differentiated problem. However, he found no significant difference in performance between the sign and non-sign-differentiated problems for global Ss. Nor did he find the performance of global Ss superior to the performance of analytic Ss on the non-sign-differentiated problem.

In summary, assuming that all three types of assessment techniques summarized here measure what has been called the analytic-global cognitive style, it would appear that it is a rather pervasive disposition or trait. Reliability estimates and validity estimates are generally moderate to high. The analytic preference appears to increase with age, possibly into early adulthood at which time it may decrease. Males tend

to be more analytic than females, but the difference may not appear until late childhood or adulthood. The preference for an analytic cognitive style appears to be related to non-verbal measures of intelligence but not to verbal measures.

In general, the analytic S is superior to the non-analytic S in many types of learning situations. Attempts to facilitate performance of global Ss through special training have not been successful. Non-analytic Ss may be more socially sensitive than analytic Ss.

Of the many tasks available to assess the analytic cognitive style, it appears that the orienting objects tasks and the embedded figures tests are more closely related to each other than to the categorizing tasks. Of the tasks available, the Hidden Figures Test (Educational Testing Service, 1962) was chosen for the present study for conceptual as well as practical reasons. As a paper-and-pencil test, it is easier to administer than the orienting tasks. It was selected over the categorizing type task because it was felt that it provides a purer measure of perceptual ability unconfounded by verbal ability than the categorizing tasks developed by Kagan and others. As Messick and Fritzky (1963) point out "Kagan's measures, by virtue of their reliance upon the evaluation of verbal labels or the expression of preference for conceptual categorization, may implicate in addition to analytic attitude certain verbal and conceptual correlates (p. 347)." Since the discrimination of attributes, the operation under investigation in this study, is largely a perceptible task, a relatively pure measure of discrimination was desirable.

Of the embedded figures tests available, the HFT was chosen because it can be administered to a group, can be objectively scored, and does not require memory. It was felt that confounding perceptual ability with memory ability would not be desirable. Discrimination of attributes would seem to rely very little on short-term memory which is required in other group forms of the embedded figures tests.

Instructional Variable--Verbal Emphasis Versus No Emphasis

Trabasso (1963) defines an emphasizer as "any stimulus which makes S more attentive to a relevant cue (p. 398)." One type of emphasizer is a verbal cue. Verbal cues can be presented during a pre-training session or during the training session. In the present study, verbal cues will be presented during training. See Frayer (1970) for a summary of studies presenting verbal cues during pre-training sessions.

Merrill and Tennyson (1971) presented the concept of trochaic meter to undergraduate educational psychology students through written materials. Four independent variables were manipulated in these materials. These variables were (a) concept definition, (b) attribute definition, (c) presentation of examples and non-examples, and (d) attribute prompting which identified the relevant attributes in each example or the absence of relevant attributes in each non-example.

Merrill and Tennyson predicted that combining attribute prompting with positive and negative examples would result in less overgeneralization than presenting only the positive and negative examples. This hypothesis was supported. They also predicted that presenting the

concept definition, positive and negative examples, definition of the attributes, and attribute prompting would result in correct classification of examples and non-examples. This condition was predicted to result in correct classification superior to presenting just the concept definition, positive and negative examples, and attribute prompting, but not the definition of the attributes. This hypothesis was not supported. Both conditions produced equally correct classification. These two conditions were superior to all conditions except for a concept definition and examples condition. Only the condition containing all four independent variables was superior to the concept definition plus examples condition. Thus, it was concluded that the attribute prompting variable was the most powerful of the four independent variables studied.

The verbal emphasizer used by Merrill and Tennyson stated the relevant attributes, thereby supplying additional information. Remstad (1969) and Frayer (1970) drew attention to the relevant attributes without explicitly stating the relevant attributes. The cues used by Remstad were verbal statements or words emphasizing certain aspects of the visual instance, e.g., for the concept trapezoid the name of the concept and the verbal cue "opposite" were presented. Of the several variables studied by Remstad, the single word verbal cues produced the largest increase in S's ability to identify instances of the various geometric concepts presented.

Frayer (1970) also presented selected geometry concepts in written materials. Her presentation included the concept definition and either two positive and two negative examples or four positive and four negative

examples. Under an emphasis condition questions were posed which were designed to direct attention to the relevant attributes of the concepts, e.g., for quadrilateral, "Does this figure have four sides?" After the presentation of the figures, attention was again focused on the relevant attributes by a question such as "How many sides does a quadrilateral have?" Frayer found a highly significant difference in performance under emphasis and no emphasis conditions. This difference was especially evident on test questions which called for the recognition of an attribute example, given the name of the attribute.

The results of these three studies indicate that emphasis in the form of verbal statements or words is effective in increasing performance in concept learning tasks. The emphasis condition used in the present study combines the emphasis conditions defined by Remstad and Frayer. At the beginning of the presentation of each concept is a cue similar to Remstad's, e.g., for parallelogram, "Pay special attention to the number of parallel sides." After each figure a question, similar to Frayer's, is presented, e.g., "How many pairs of parallel sides are there?" Like Remstad's and Frayer's emphasis condition, no substantive additional information is provided in the emphasis condition of the present study.

Methodology

Subjects

The initial sample consisted of 108 seventh-grade students from four mathematics classes in Benjamin Franklin Junior High School, Stevens Point, Wisconsin. Only analytic and non-analytic Ss were included in this study.

Analytic Ss were defined as those who scored in the upper third of the initial distribution of HFT scores and non-analytic were defined as those who scored in the lower third of the initial distribution of HFT scores. Therefore, the 36 Ss who fell in the middle were eliminated. The scores of the analytic Ss ranged from 17.50 to 6.50 (mean = 9.92) and the scores for the non-analytic Ss ranged from 3.50 to -4.25 (mean = .43). Of the remaining 72 Ss, 5 were lost because of absences so that the results were based on 67 Ss. A questionnaire (Appendix A) completed by the students' mathematics teachers indicated that about 58 percent of the Ss in the initial sample had some knowledge of the concept parallelogram, and 7 percent had mastered the concept. About 30 percent had some knowledge of the concepts trapezoid and rhombus.

Materials

Geometry Lesson I, Geometry Lesson II (emphasis), Geometry Lesson II (no emphasis), Test of Geometry Knowledge: Form PRT, and the Hidden Figures Test (Educational Testing Service, 1962) were used.

The Hidden Figures Test is a group-administered test which discriminates Ss who are able to see simple figures in complex patterns (analytic) from those who are not able to see the figures (non-analytic). S is required to determine which one of five simple figures is embedded in each of 32 complex patterns. The test is comprised of two parts, consisting of 16 complex patterns each. Ten minutes are allowed for each part. The score is the total number correct minus one fourth of the number which were incorrect.

Procedure

The Hidden Figures Test was administered two weeks prior to the beginning of the geometry lesson sequence. (Note: Since seventh graders are at the lower end of the range of appropriateness for the HFT, 12 minutes were allowed for each part in this study.) On the basis of these scores, Ss were divided into three groups. The top third (N = 36) were labeled analytic and the bottom third were labeled non-analytic. The middle third were dropped from the study.

Ss in the top and bottom thirds of the distribution were stratified on sex and randomly assigned to either the emphasis or no emphasis condition.

On Day 1 Ss in both conditions studied the introductory lesson, Geometry Lesson I. On Day 2 Ss in the emphasis condition studied Geometry Lesson II (emphasis) and were administered the Test of Geometry Knowledge: Form PRT immediately upon completion of the lesson. Ss in the no emphasis condition studied Geometry Lesson II (no emphasis) and were administered the Test of Geometry Knowledge: Form PRT immediately upon completion of the lesson.

All materials were prepackaged for each S by day and class, with the S's name on the envelope. On Day 1 the proctor distributed the envelopes which contained rulers, cardboard strips (used to cover the answers listed in the right-hand column of the lesson) and Geometry Lesson I. Instructions (Appendix B) concerning the procedure to be followed in completing the lessons were read to the students. Each student recorded the starting time and studied his lesson on an individual basis. Upon completion of his lesson the student recorded his finishing

time and worked on an assignment given by the classroom teacher.

On Day 2 the same general procedure was followed. Envelopes containing rulers and lessons were distributed. Instructions (Appendix B) were read to the Ss. Difficult words, listed on the first page of the lessons, were read to the Ss and any questions concerning procedure were answered. Each student recorded his starting time and studied his lesson independently. Upon completion of the lesson he recorded his finishing time, raised his hand, and received the test.

Design

The experimental design was a 2 x 2 x 2 factorial with two levels of cognitive style (analytic and non-analytic), two categories of sex, and two treatments (emphasis and no emphasis).

Results

Psychometric Characteristics of Geometry Test

An item analysis (Baker & Martin, 1968) was performed on the scores on Test of Geometry Knowledge: Form PRT for all Ss in both studies (N = 200) who completed the lesson and test sequence. The 126-item test had a Hoyt reliability estimate of .87. The Hoyt reliability estimate was .84 for the 36 Type I items, .75 for the 36 Type II items, and .81 for the 54 Type III items.

Hypotheses

The following hypotheses were investigated.

1. Analytic Ss will perform significantly better on
    a. a test assessing attainment of the concepts, and

b. items assessing discrimination of attributes than non-analytic Ss.

2. Ss who study the emphasis lesson will perform significantly better on

   a. a test assessing attainment of the concepts, and

   b. items assessing discrimination of attributes than Ss who study the no emphasis lesson.

3. The difference in performance between emphasis and no emphasis conditions as assessed by

   a. a test measuring the attainment of the concepts, and

   b. items measuring the discrimination of attributes

   will be greater for non-analytic Ss than for analytic Ss.

Several dependent measures were obtained for each S. A total score and scores for each type of item were obtained from the Test of Geometry Knowledge: Form PRT. The Hidden Figures Test yielded a score based on the number of figures correctly identified minus 1/4 the number incorrectly identified. In addition, Reading and Arithmetic subtest scores from the Iowa Test of Basic Skills and Kuhlmann-Anderson IQs were obtained from students' records. A teacher estimated the IQ of one S who was not present at the time of IQ testing. The mean of all Ss was substituted for any missing Arithmetic and Reading scores.

Two main analyses were performed. One analysis involved the total test score. This analysis examined the effects of the analytic-global cognitive style and the emphasis-no emphasis treatment conditions on attainment of the concepts at the formal level. Attainment of a concept

at the formal level implies that S can (a) name the defining attributes of the concept, (b) evaluate instances to determine whether they are examples or non-examples of the concept, and (c) define the concept. Therefore, scores on items reflecting each of these capabilities were combined to yield a total test score. A univariate analysis of covariance with IQ as the covariate was performed on this score. Means and standard deviations for IQ are presented in Appendix E.

A second analysis involved item Type I questions which measured the ability to name the relevant attributes of the concept. Two multivariate analyses of covariance on individual item types were performed to determine whether the effect of cognitive style and treatment was more pronounced for item Type I than for item Types II and III. Finn's (1968) multivariate computer program was used for all of the analyses of covariance. Since the number of Ss in the cells varied, the design was nonorthogonal. In all analyses, the effects were tested in the order indicated in the summary tables.

In addition to the analyses of covariance, correlations among HFT scores, reading achievement, arithmetic achievement, IQ, and total test score were obtained. The mean times required to complete each type of geometry lesson were also calculated.

Univariate Analysis of Covariance on Total Test Scores

Table 6 presents the observed means and standard deviations for item type scores and total test scores for each experimental group by sex. The number of subjects in each group is also noted. A univariate

Table 6

Number of Subjects in Each Experimental Group by Sex and Observed Means and Standard Deviations

for the Three Item Types and Total Scores in Study I

Treat-ment	Item Type	Cognitive Style: Analytic Males	Analytic Females	Non-Analytic Males	Non-Analytic Females	M
Emphasis	1	34.00 (2.31)	32.55 (2.77)	31.50 (4.04)	27.00 (4.14)	31.29
	2	29.29 (3.86)	26.00 (4.82)	27.75 (4.65)	24.88 (4.45)	26.82
	3	39.14 (2.79)	38.82 (4.42)	35.75 (8.56)	32.38 (3.96)	36.65
	Total	102.43 (5.56)	97.36 (8.04)	95.00 (14.51)	84.25 (9.82)	94.76
		N = 7 (0)	N = 11 (0)	N = 8 (2)	N = 8 (0)	N = 34
No Emphasis	1	30.33 (4.68)	31.60 (3.86)	26.56 (5.83)	25.50 (3.82)	28.52
	2	27.00 (4.20)	28.30 (5.19)	25.22 (3.67)	26.38 (3.46)	26.76
	3	33.17 (6.79)	37.80 (6.75)	30.89 (5.04)	32.63 (5.29)	33.82
	Total	90.50 (10.45)	97.70 (12.95)	82.67 (9.03)	84.50 (9.68)	89.09
		N = 6 (1)	N = 10 (1)	N = 9 (1)	N = 8 (0)	N = 33
M	1	32.18		27.61		
	2	27.53		26.03		
	3	37.59		32.85		
	Total	97.29 N = 34		86.48 N = 33		

Note.--Standard deviations and number of Ss lost are given in parentheses.

analysis of covariance was performed on the total test scores. The results of this analysis are presented in Table 7.

Table 7

Univariate Analysis of Covariance on Total Scores for Study I

Source	df	MS	F	p<
IQ (Covariate)	1	825.99	8.68	.0047*
Analysis of Covariance				
Sex	1	67.46	.71	.40
Cognitive Style	1	444.12	4.67	.03*
Sex x Cognitive Style	1	73.53	.77	.38
Treatment	1	293.12	3.08	.08
Treatment x Cognitive Style	1	17.77	.19	.67
Treatment x Sex and Treatment x Sex x Cognitive Style	2	244.34	2.57	.09
Between Subjects within Cells (Error)	58	95.16		

Note.--All effects were tested in the order presented.
*Significant at or beyond the .05 level chosen.

Of interest to this study are the cognitive style effect, the treatment effect, and the cognitive style by treatment interaction. Of these three, only cognitive style was significant. Analytic Ss demonstrated performance which was superior to the performance of non-analytic Ss; the mean total score for analytic Ss was 97.29, while the mean total score for non-analytic Ss was 86.48. The .08 probability level of treatment suggests that there may be a difference between

treatments but not significant at the .05 chosen level. There was no treatment by cognitive style interaction. IQ was significantly related to test performance.

Multivariate Analysis of Item Types

It was predicted that a greater difference would be evident between analytic and non-analytic Ss and between emphasis and no emphasis treatment conditions in performance on item Type I than on total test score. A multivariate analysis of covariance (Table 8) was performed on the scores for the three item types. In addition, a multivariate analysis of covariance was performed on two contrasts, Type I-Type II and Type I-Type III. The results of this analysis are presented in Table 9.

The overall multivariate analysis of the three item types revealed that the main effect of treatment was significant at the .08 level and the main effect of cognitive style at the .06 level. Neither was significant at the .05 level. However, the univariate analysis of scores on item Type I indicated that there were significant differences between analytic and global cognitive styles ($p < .007$) and between emphasis and no emphasis treatment conditions ($p < .02$) on this item type. Based on the univariate analysis of item Type I, it appears that analytic Ss performed better than non-analytic Ss and that Ss studying the emphasis lessons performed better than Ss studying the no emphasis lessons. The nonsignificant treatment by sex and treatment by sex by cognitive style interaction suggests that this effect is unbiased. There was no significant treatment by cognitive style interaction, however, either for the multivariate analysis or for any of the univariate analyses.

Table 8

Multivariate Analysis of Covariance of Item Type Scores in Study I

Source	df	Multivariate	Univariate Type I	Type II	Type III
IQ (Covariate)	3	<.03*	<.02*	<.25	<.01*
Analysis of Covariance					
Sex	3	<.35			
Cognitive Style	3	<.06	<.007	<.55	<.17
Sex x Cognitive Style	3	<.58			
Treatment	3	<.08	<.02*	<.87	<.12
Treatment x Cognitive Style	3	<.81			
Treatment x Sex and Treatment x Sex x Cognitive Style	6	<.53			
Between Subjects within Cells (Error)	58	MS = 107.55	15.12	19.10	29.21

Note.--All effects were tested in the order presented.
*Significant at or beyond the .05 level chosen.

The multivariate analysis of contrasts revealed a significant effect of cognitive style. This effect appeared to be due to the item Type I-II contrast. As in the previous analysis, the multivariate analysis of treatment effect was significant at the .10 level but not at the .05 chosen level. This result also appeared to be due to the item Type I-II contrast. The treatment by cognitive style interaction was not significant.

From these three analyses it may be concluded that there is a difference between the performance of analytic and non-analytic Ss. This difference appears to be greatest on item Type I. There is some indication that there may be a difference between the emphasis and no emphasis

Table 9

Multivariate Analysis of Covariance of Contrasts

Between Item Type Scores in Study I

Source	df	Multivariate	Univariate Item 1-2	Univariate Item 1-3
IQ (Covariate)	2	<.27		
Analysis of Variance (IQ not removed)				
Sex	2	<.28		
Cognitive Style	2	<.04*	<.02*	<.94
Sex x Cognitive Style	2	<.50		
Treatment	2	<.10	<.05*	<.98
Treatment x Cognitive Style	2	<.78		
Treatment x Sex and Treatment x Sex x Cognitive Style	4	<.97		
Between Subjects within Cells (Error)	58	MS = 107.55	32.44	29.64

Note.--All effects were tested in the order presented.
*Significant at or beyond the .05 level chosen.

conditions. The univariate analysis of total score and the multivariate analysis of item type scores did not show an effect significant at the .05 level. However, all levels were at or below .10. The univariate analysis of item Type I suggests that there may be a difference. There is no treatment by cognitive style interaction.

IQ appears to be related to performance on the Test of Geometry Knowledge, especially on item Type I which calls for knowledge of

relevant attributes and item Type III which calls for defining the concepts.

The first hypothesis, that analytic Ss would perform better than non-analytic Ss is supported both in terms of attainment of the concepts as defined by a combination of the three item types and in terms of the ability to discriminate attributes.

The second hypothesis, that the emphasis lesson would result in better performance than the no emphasis lesson, receives minimal support. There was no significant difference in attainment of the concepts, as measured by the total test, as a result of treatment condition, but there may be a difference among Ss in their ability to discriminate relevant attributes as a function of lesson type.

No treatment by cognitive style interaction was found for either general attainment of the concept or knowledge of relevant attributes. Thus, the third hypothesis, that non-analytic Ss would benefit more from the emphasis lesson than analytic Ss, was not supported. The actual differences in the estimated means of the groups, however, are in the predicted directions. Table 10 presents the estimated means for the total score and item Type I scores. The difference between emphasis and no emphasis means for total scores for analytic Ss is 5.80; for non-analytic Ss the difference is 6.05. The difference between emphasis and no emphasis means for item Type I scores for analytic Ss is 2.30; for non-analytic Ss the difference is 3.22. Although the means were in the predicted direction, the interaction was not significant. Figures 1 and 2 illustrate the pattern of means for the cognitive style by treatment groups for total test score and for item Type I.

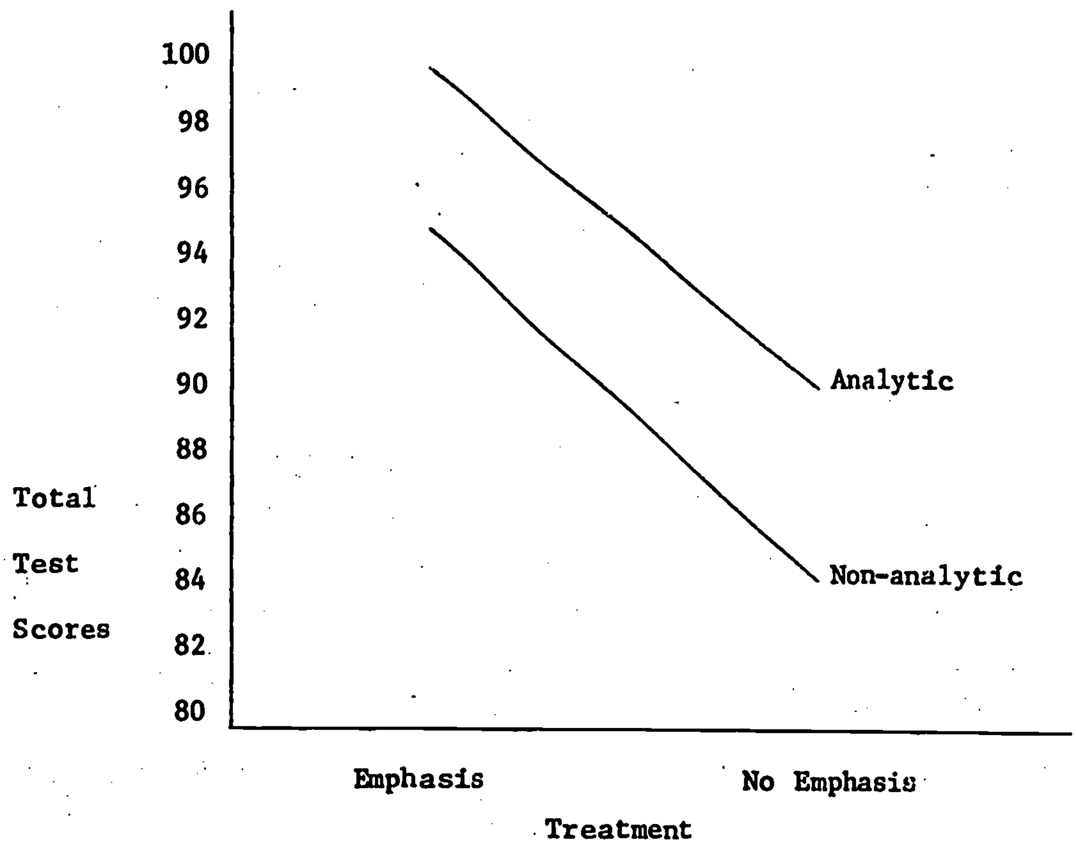

Fig. 1. Estimated means of total test scores for analytic and non-analytic Ss under the emphasis and no emphasis treatment conditions.

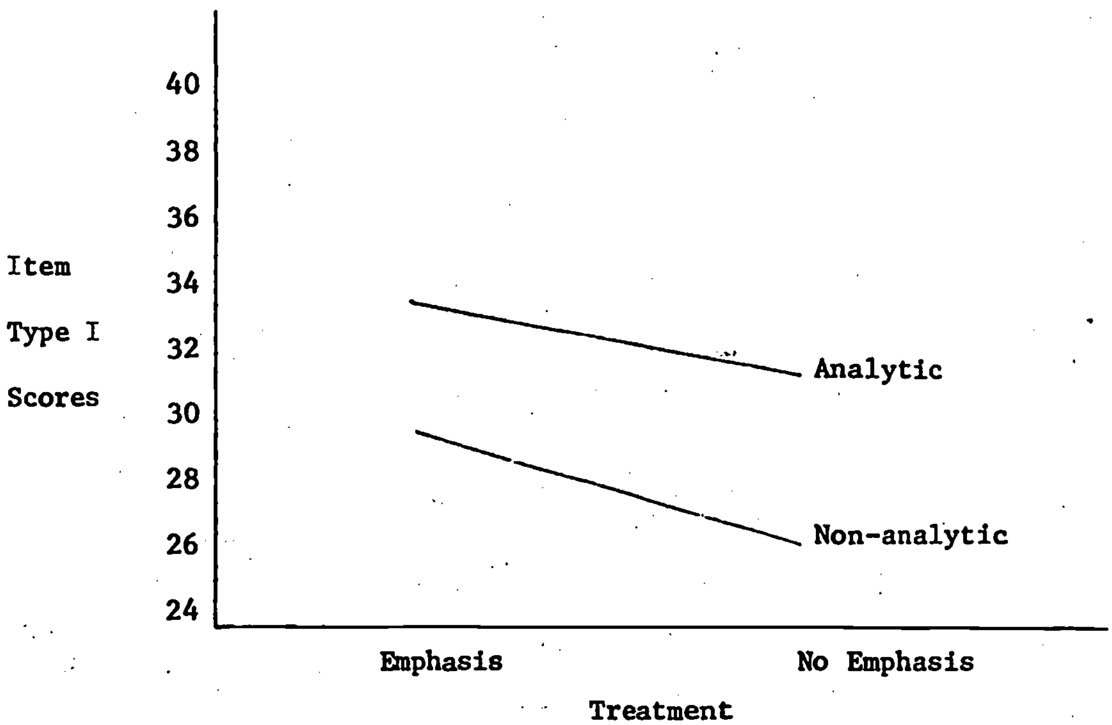

Fig. 2. Estimated means of item Type I scores for analytic and non-analytic Ss under emphasis and no emphasis treatment conditions.

Correlations Among Selected Dependent Variables

Table 11 presents the correlations among HFT scores, reading achievement, and arithmetic achievement as assessed by the Iowa Test of Basic Skills, IQ as assessed by the Kuhlmann-Anderson, and the total test score on the Test of Geometry Knowledge: Form PRT. As expected, performance on the geometry test was significantly related to arithmetic achievement, reading achievement, and IQ. Performance on the geometry test was also significantly related to performance on the Hidden Figures Test. Performance on the Hidden Figures Test was related to IQ but not to reading or arithmetic achievement.

Table 10

Estimated Combined Means for Item Type I and Total Test Score for Treatment by Cognitive Style Groups in Study I

Treatment			Cognitive Style: Analytic	Global	M
	Emphasis	Item Type I	33.27	29.25	31.26
		Total	99.90	89.63	94.76
			N = 18	N = 16	N = 34
	No Emphasis	Item Type I	30.97	26.03	29.50
		Total	94.10	83.58	88.84
			N = 16	N = 17	N = 33
			32.12	27.64	
			97.00	86.60	
			N = 34	N = 33	

Table 11

Correlations Among Selected Dependent Variables for the 67 Ss in Study I

		HFT	Reading	Arithmetic	IQ	PRT
1	HFT	1.00				
2	Reading Achievement	.35	1.00			
3	Arithmetic Achievement	.39	.36	1.00		
4	IQ	.52*	.49*	.55*	1.00	
5	Total PRT Score	.48*	.46*	.44*	.53*	1.00

Note.--Correlations <-.41 or >.41 are significant at the .05 level for a two-tailed test.

Chapter IV

REVIEW OF RELEVANT LITERATURE, METHODOLOGY AND RESULTS FOR STUDY II

The purpose of Study II was to examine the effect of the reflective-impulsive cognitive style on the immediate acquisition of selected geometry concepts presented under one of two treatment conditions, discovery or expository.

Review of Relevant Literature

Organismic Variable--Reflectivity versus Impulsivity

> The reflection--impulsivity dimension describes the degree to which a child reflects upon the differential validity of alternative solution hypotheses in situations where many response possibilities are available simultaneously. In these problem situations the children with fast tempos impulsively report the first hypothesis that occurs to them, and this response is typically incorrect. The reflective child, on the other hand, delays a long time before reporting a solution hypothesis and is usually correct (Kagan, 1966a, p. 119).

The tasks most often used to assess a reflective-impulsive cognitive style or conceptual tempo require S to study a target item and then to pick out an identical copy of the target from among several variants. Two scores are derived, latency to first choice and number of errors. Research on reflectivity-impulsivity has usually employed one of three tests based on this general matching task. These tests are the Design Recall Test, the Matching Familiar Figures test, and the Haptic-Visual

Matching test. These three tests resulted from a series of studies by Kagan, Rosman, Day, Albert and Phillips (1964).

The Design Recall Test (DRT) involves the presentation of a simple line drawing of a geometric design to S for 15 seconds, removal of the design for 15 seconds, and then a second presentation in which the design is presented along with several variants. S is required to select the design from among the variants. The Matching Familiar Figures test (MFF) is similar to the DRT but employs meaningful pictures (trees, beds, cowboys) rather than geometric designs. The standard form, which is appropriate for use with young children, consists of 12 items each of which has six variants. The adult form also consists of 12 items, but each item has eight variants. A dual criterion, based on errors and response latencies, defines reflective and impulsive Ss. A reflective S is one who has above the median response latencies and below the median errors, while an impulsive S is one who has above the median errors and below the median response latencies. There is a high negative correlation between response latency and errors.

The Haptic-Visual Matching (HVM) test measures the reflectivity-impulsivity cognitive style with a cross-modal task. S tactually explores a three-dimensional wooden geometric form or familiar object to which he has no visual access. Then, he must select from a 5-variant visual array the form he explored tactually. In addition to response latency and error scores, the time taken to tactually explore the form is recorded.

Coefficients of stability on these tests have been low to moderate. Messer (1970) reports moderate but significant correlations ranging from .25 to .43 for the MFF administered to first-grade boys and re-administered 2 1/2 years later. Yando and Kagan (1968) found that the stability of response latencies on the MFF was .70 for first-grade girls and .13 for first-grade boys. Error scores showed low stability for both sexes over a nine-month period. Siegelman (1969) reported a test-retest correlation of .73 for fourth-grade boys. The time interval between administrations was not stated but may be assumed to be short.

The validity estimates, or correlations among the various measures, showed greater consistency. Messer (1970) found a significant relationship between performance on the HVM and performance on the MFF for first-grade boys. Kagan, Pearson and Welch (1966) and Kagan (1966a) also reported a relationship between scores on the HVM or MFF for first graders. Kagan, et al. (1964) reported positive correlations among the DRT, HVM and MFF for third graders.

Little work has been done in establishing age trends and sex differences in performance on these tests. Lewis, Rousch, Goldberg and Dodd (1968) found no difference between boys and girls (mean age of 44 months) on a matching figures test similar to the MFF. Meichenbaum and Goodman (1969) found that female kindergarten Ss took significantly longer to respond to MFF items than males. Kagan, Pearson and Welch (1966a) found that girls displayed greater intertask consistency for the reflectivity-impulsivity cognitive style than boys.

The relationship of conceptual tempo to IQ is not clear. Kagan, et al. (1964, Study 2) found that the MFF error scores and latencies were not related to verbal subtests of the WISC. However, they found low negative correlations between error scores on the HVM, DRT and MFF and IQ as measured by the California Test of Mental Maturity but no relationship between latency and IQ. Kagan, Pearson and Welch (1966a) found that errors on the MFF and HVM were negatively correlated with WISC verbal scores but response time was independent of IQ. Meichenbaum and Goodman (1969) found that reflective Ss scored higher on verbal meaning, perceptual speed, number facility and spatial ability subtests of the Primary Mental Abilities Test than impulsive Ss. Ward (1968) found low positive correlations between MFF response times and mental age as measured by the Peabody Picture Vocabulary Test. Errors and response time are significantly correlated with the Stanford-Binet IQ for girls but not for boys (Lewis, Rousch & Goldberg, 1968). From these results it appears that the relationship between conceptual tempo and IQ is dependent upon the test used to assess IQ and possibly the sex of the subjects. These inconclusive results are due, in part, to the fact that most of the studies used Ss who were very young and measures of IQ are not very reliable in young children.

Most of the research on conceptual tempo has been conducted with children and has reflected two orientations. One group of studies attempts to relate the reflectivity-impulsivity dimension to other variables especially variables related to school achievement. A second group of studies deals with the problem of modifying the impulsive tempo.

Relationship of Reflectivity-Impulsivity to Other Variables

Kagan (1966a) investigated the relationship between conceptual impulsivity and body build. He administered the MFF to first, third, fourth and fifth graders and obtained measures of height and chest girth. He found a relationship between conceptual tempo and body build for boys. Short-broad boys tended to be impulsive, while tall-thin boys tended to be reflective. This relationship appeared to develop somewhere during the 8 to 10-year old range; it was not evident in first-grade boys.

Two studies dealt with the effect of the reflectivity-impulsivity predisposition on psychomotor behavior. Barratt (1959) examined the effect of impulsiveness and anxiety on a mirror tracing task. The Impulsiveness Scale of the Thurstone Temperament Schedule was administered to the university Ss to identify reflectives and impulsives. Barratt found that high impulsive-low anxious Ss made a higher percentage of errors than the low impulsive-high anxious Ss. High impulsives-low anxious Ss made a higher percentage of errors than the high impulsive-high anxious Ss. These results suggest that anxiety may tend to inhibit impulsiveness in some instances.

Meichenbaum and Goodman (1969) investigated the relationship between the ability to verbally control motor behavior and the reflectivity-impulsivity dimension. Kindergarten children were administered a finger tapping task during which they covertly or overtly verbalized either "faster" or "slower" and a pedal pushing task during which they covertly or overtly verbalized either "push" or "don't push." Tapping performance of the impulsive Ss did not differ from that of the reflective Ss under either covert or

overt verbalization conditions. However, impulsive Ss verbalized the words more frequently than reflective Ss under both conditions. On the foot pedal task, impulsive Ss made more errors under the covert verbalization condition only. Under both conditions impulsive Ss tended to press harder and hold the pedal down longer than reflective Ss.

Three studies examined the effect of conceptual tempo on cognitive tasks such as concept learning (Kagan, 1966b), inductive reasoning (Kagan, Pearson & Welch, 1966a) and reading ability (Kagan, 1965b). Messer (1970) related conceptual tempo to school failure.

Kagan (1966b) looked at the effect of reflectivity-impulsivity on concept learning under experimentally-induced feelings of anxiety and rejection. The MFF was used to define impulsive and reflective third graders. All Ss learned two lists of 12 familiar words each. Six words in each list belonged to a conceptual category and were surrounded by six words unrelated to the concept. Ss in the "threat" group were told to try hard because these lists would be hard. This prewarning was expected to arouse anxiety over possible failure. Ss in the "rejection" group were told that they did poorly on the first two lists. This communication was expected to arouse anxiety over the examiner's disapproval. Dependent variables were (a) number of concept words recalled, (b) number of non-concept words recalled, and (c) number of intrusion errors.

Reflective Ss recalled more concept and non-concept words than impulsive Ss. Impulsive Ss made more intrusion errors than reflective Ss. There was only one significant difference between groups--reflective Ss,

2 1/2 years later. Those who failed a grade were more impulsive than those who did not. There was no difference between these groups on verbal intelligence.

Attempts to Modify the Impulsive Tempo

The results of the studies just cited suggest that the reflective child has a definite advantage over the impulsive child, especially on tasks which are important in school achievement. Recognizing the benefits of the reflective attitude, researchers have attempted to train the impulsive child to become more reflective.

One of the differences between the performance of reflective and impulsive Ss appears in the time taken to study the alternatives presented. Siegelman (1969) found that not only did reflective Ss spend more time looking at the alternatives, they looked at more of the alternatives and distributed their attention more equally among the alternatives than impulsive Ss. A second difference between reflective and impulsive Ss occurs in the number of errors made; impulsive Ss tend to choose more incorrect variants than reflective Ss. Kagan, Pearson and Welch (1966b) and Yando and Kagan (1968) succeeded in increasing response times of impulsive Ss but failed to decrease errors.

Kagan, Pearson and Welch (1966b) hypothesized that impulsive Ss who perceive themselves similar to a reflective experimenter would tend to model their behavior after that of the experimenter and become more reflective. Impulsive first-grade boys and girls were administered training tasks designed to increase reflectiveness under one of two conditions,

high perceived similarity to trainer and low perceived similarity to trainer. The three training tasks, a design matching task, an inductive reasoning task and a haptic visual matching task, required S to wait for 10 to 15 seconds before responding. Before beginning the tasks, E told Ss in the high-similarity group that he and they were similar in many ways and that he was reflective and valued the quality of reflection. Ss in the low similarity group did not receive this communication.

The only important effect of training was to lengthen response times on the MFF. Ss in both the high- and low-similarity groups showed greater increases in response time between the pre- and post-training administrations of the MFF than did control Ss. There was no significant changes in error scores. The predicted differential effect of training under high or low perceived similarity was not evident.

Yando and Kagan (1968) also used a modeling procedure in an attempt to modify an impulsive tempo. Ten impulsive and ten reflective first-grade teachers were identified on the basis of their scores on the adult form of the MFF. Children from each of these teachers' classes were randomly selected and administered the standard form of the MFF. They were readministered a second form of the MFF at the end of the school year.

There was no significant decrease in errors during the year, but latencies were affected; boys and girls in the classrooms of experienced, reflective teachers showed increases in response times over the academic year. Boys in the classrooms of experienced, reflective teachers showed larger increases in response times than boys in the classrooms of experienced, impulsive teachers or inexperienced, reflective teachers.

It appears that modeling increases the response times of impulsive Ss but does not decrease their errors. Isakson and Moore (1972) attempted to reduce the errors made by impulsive Ss by training them to use detail, i.e., to process information analytically. Impulsive Ss were identified by administering a modified version of the MFF. These Ss were randomly assigned to an experimental or a control group. Ss in the experimental group were given three training tasks, Analytic Relationship Training (ART), Detail Recall Training (DRT), and Detail Matching Training (DMT). The ART task required S to select two of three pictures which went together. E reinforced pair selections based on similar details. The DRT task required S to answer questions about a picture he had seen. The DMT task required S to choose a detail that matched a detail in a drawing he was shown briefly. After experimental Ss completed training, both groups were administered the MFF. Isakson and Moore found that Ss in the experimental group made significantly fewer errors than Ss in the control group. There was no significant difference between groups on latency, however.

Relationship Between the Analytic-Global and Reflectivity-Impulsivity Cognitive Style Dimensions

The results reported by Isakson and Moore suggest that there may be a relationship between the analytic-global cognitive style and the reflectivity-impulsivity cognitive style. They found that training in analysis decreased errors on the MFF. Kagan, Rosman, Day, Albert and Phillips (1964) also suggest that these two cognitive style dimensions are related.

Through a series of studies, Kagan, et al. reached the conclusion that "2 more fundamental cognitive dispositions each contribute variance to the production of analytic concepts: the tendency to reflect over alternative solutions or classifications in situations in which several response alternatives are available simultaneously, and the tendency to analyze visual arrays into their component parts" (p. 1). This conclusion was based on several lines of evidence. Reaction times for emitting analytic concepts were significantly longer than for relational concepts (Kagan, et al. 1963). Ss who were encouraged to respond slowly, i.e., to reflect before responding, produced more analytic responses on the Conceptual Style Test (Kagan, et al. 1964, Study 2). The production of analytic responses was negatively related to error scores on the MFF (Kagan, et al. 1964, Study 5).

In summary, the reflectivity-impulsivity cognitive style dimension appears to produce reliable differences in tasks requiring S to select a standard from among variants. Reflective Ss tend to make fewer errors and to study the stimuli longer than impulsive Ss. It has also been found that reflective Ss have greater verbal control over motor behavior, are better on concept learning tasks, make fewer errors on inductive reasoning tasks and make higher scores on word recognition tasks than impulsive Ss. Impulsive Ss are more apt to be held back a grade. The relationship between tempo and IQ is not clearcut. The relationship is possibly dependent upon the IQ test and the age and sex of the subjects.

Attempts to train impulsive Ss to be more reflective have met with only limited success. Modeling techniques succeeded in increasing latencies

but failed to reduce errors. Training in analytic techniques succeeded in reducing errors but failed to increase latencies.

There is some evidence that the reflectivity-impulsivity attitude may account for some of the variance in performance on tasks assessing the analytic-global preference.

Instructional Variable--Discovery versus Expository Learning

The controversy surrounding the differential benefits of a discovery method versus an expository method of presenting instructional material has existed for many years but has led to few definitive conclusions. This lack of resolution has been due, in part, to the absence of operational definitions of discovery learning and expository learning and to the wide range of treatments used to investigate these types of learning. Nelson and Frayer (1972) summarize many of the studies comparing an expository method with a discovery method of instruction. They concluded that two confounding variables frequently preclude a straightforward interpretation of apparent differences between expository and discovery methods: (a) lack of adherence to each method and (b) differences in mode of presentation between the two methods, e.g., teacher verbalizations for one method, written materials for the other. Nelson and Frayer recommend that a more direct comparison of the two methods could be made if these sources of variability were eliminated through the use of a standardized learning task. Scott and Frayer (1970) describe such a task. The task has been subsequently used by Scott (1970) and Nelson and Frayer (1972), and was also employed in the present study. The main characteristic

used. Unlike Scott they found a difference between groups on immediate acquisition; Ss in the expository group had significantly higher scores than Ss in the discovery group. The results for retention were not as clearcut. An independent groups analysis revealed no difference between groups. A repeated measures analysis revealed that Ss in the discovery group tended to forget less than Ss in the expository group over a 21-day retention interval. Nelson and Frayer concluded that method of presentation affected immediate acquisition and may have affected retention. They found that the expository lessons required about 1/2 as much time as the discovery lessons, which led to the conclusion that the expository method was more "efficient" than the discovery method.

Scott (1970) and Nelson and Frayer (1972) used a task that eliminated some of the effects of confounding variables. Material was presented entirely through written lessons. Egan and Greeno (1972) compared discovery and "rule learning" methods of presentation through the use of programmed booklets and computer-assisted instruction (CAI). Their methods also exercised control over some of the confounding variables evident in earlier studies. Egan and Greeno taught the concepts of binomial probability and joint probability to university students under discovery and rule learning methods of presentation. Subjects in the discovery group solved problems and arrived at generalizations. Partial definitions were provided after solving various sections of the instructional sequence. Subjects in the rule learning group were provided a formula and relevant definitions at the beginning of the lesson. All questions were related to the formula.

Egan and Greeno found no significant difference in the effectiveness of the two instructional methods. However, Ss low in computational and mathematics-related conceptual abilities performed better under the rule learning condition than under the discovery condition. Neither Scott nor Nelson and Frayer found a relationship between general arithmetic ability and method used to teach geometric concepts. The fact that Egan and Greeno used ability tests specific to probability learning may account for this difference.

The present study follows the methodology used by Scott (1970) and Nelson and Frayer (1972). The expository method is similar to that of Scott and Nelson and Frayer. A concept definition is presented, followed by figures which are labeled as examples or non-examples. Explanations of why a figure is or is not an example of the concept follows each figure. The discovery method used in the present study differs from that used previously. The name of the concept is presented at the beginning of the instructional sequence, and each figure is labeled as an example or non-example of the concept. S is asked to compare figures and state how examples are alike and how examples differ from non-examples. Unlike Scott's and Nelson and Frayer's discovery condition, no feedback is given for the summary questions at the end of the presentation of each concept.

Methodology

Subjects

The initial sample consisted of 107 seventh-grade students from four mathematics classes not involved in Study I in Benjamin Franklin Junior

High School, Stevens Point, Wisconsin, Forty-five Ss were eliminated on the basis of their performance of the MFF. Of the remaining 62 Ss 9 were lost because of absenses so that the results were based on 53 Ss. A questionnaire (Appendix A) completed by the teachers indicated that about 37 percent of Ss in the initial sample had some knowledge of the concept parallelogram and about 4 percent had mastered the concept parallelogram. About 18 percent had some knowledge of the concepts trapezoid and rhombus.

Materials

Geometry Lesson I, Geometry Lesson II (discovery), Geometry Lesson II (expository), Test of Geometry Knowledge: Form PRT, and the standard form of the Matching Familiar Figures test (Kagan, et al. 1964) were used.

Procedure

The MFF was individually administered to Ss by one of three examiners approximately two weeks prior to the beginning of the geometry lesson sequence. This test was used to categorize Ss as impulsive or reflective. Table 6 gives the numbers of males and females falling above and below the median for latency and for number of errors on the MFF. The mean error score for impulsive Ss was 12.62 and for reflective Ss was 5.37. The mean latency score for impulsive Ss was 75.82 and for reflective Ss was 167.51

The 18 females and 11 males who were above the median in errors and below the median for latency (impulsive) and the 17 females and 16 males who were below the median in errors and above the median for latency

Table 12

Number of Males and Females Falling Above and Below the Median for Latency and for Number of Errors on the Matching Familiar Figures Test

		Errors	
		Above Median	Below Median
Latency	Above Median	11 Females 7 Males	17 Females 16 Males
	Below Median	18 Females 11 Males	4 Females 8 Males

Note.--The error scores of 14 Ss fell at the median and the latency score of 1 S fell at the median. These Ss were not classified.

(reflective) were randomly assigned to either the discovery or expository condition.

On Day 1 Ss in both conditions received the introductory lesson, Geometry Lesson I. On Day 2 Ss in the discovery condition studied Geometry Lesson II (discovery) and took the Test of Geometry Knowledge: Form PRT immediately after completion of the lesson. Ss in the expository condition studied Geometry Lesson II (expository) and took the Test of Geometry Knowledge: Form PRT immediately after completion of the lesson.

The materials were prepackaged the same way as in Main Study I. The procedures were also the same.

Design

The experimental design was a 2 x 2 x 2 factorial with two levels of cognitive style (impulsive and reflective), two categories of sex, and two treatments (discovery and expository).

Results

Psychometric Characteristics of Geometry Test

Hoyt reliabilities for the total score and item type scores on the Test of Geometry Knowledge: Form PRT are presented in Chapter III.

Hypotheses

The following hypotheses were investigated:

1. Reflective Ss will perform significantly better on
   a. a test assessing attainment of the concepts, and
   b. items assessing inferences of the defining attributes of the concepts than impulsive Ss.
2. Ss who study the expository lesson will perform significantly better on
   a. a test assessing attainment of the concepts, and
   b. items assessing inference of the defining attributes of the concepts than Ss who study the discovery lesson.
3. The difference in performance between expository and discovery conditions as assessed by
   a. a test measuring the attainment of the concepts, and
   b. items measuring inferences of the defining attributes of the concepts will be greater for impulsive Ss than for reflective Ss.

Several dependent measures were obtained for each S. A total score and scores for each of the three item types were obtained from the Test of Geometry Knowledge: From PRT. The Matching Familiar Figures Test

yielded a total error score and a total latency score across the twelve items that comprise the test. In addition, reading and arithmetic subtest scores on the Iowa Test of Basic Skills and Kuhlmann-Anderson IQs were obtained from students' records. Teachers estimated the IQ of one S who had no IQ score. The mean of all Ss was substituted for missing arithmetic and reading scores. The time taken by each S to complete the two lessons was also available.

As in Study I, two analyses were performed, one analysis examined the effects of reflectivity-impulsivity cognitive style and discovery and expository treatment conditions on the general attainment of all three concepts at the formal level. A univariate analysis of covariance was performed on the total test scores. Means and standard deviations for IQ scores, the covariate, are presented in Appendix E. A second analysis examined performance on item Type III which assessed Ss' ability to make inferences about the concepts, i.e., to formulate a definition consisting of relevant attributes. Two multivariate analyses of covariance, on individual item types were performed to determine whether the effect of cognitive style and treatment was more pronounced for item Type III than for item Type I and II.

Finn's (1968) multivariate computer program was used for all of these analyses. Since the number of Ss in the cells varied, the design was nonorthogonal. In all analyses the effects were tested on the order indicated in the summary tables.

In addition, correlations among MFF errors, MFF latencies, reading achievement, arithmetic achievement, IQ, and total geometry test scores

were obtained. The mean times taken to complete each type of geometry lesson were also calculated.

Univariate Analysis of Covariance on Total Test Score

Table 13 lists the observed means and standard deviations of total test scores for experimental groups by sex. A univariate analysis of covariance was performed on the total test scores. The results of this analysis are presented in Table 14.

The cognitive style main effect, treatment main effect, and cognitive style by treatment interaction were of interest. Of the three, only the treatment effect was significant. The expository lessons produced higher total scores than the discovery lessons; the mean score for the expository group was 93.14, while the mean score for the discovery group was 83.63. IQ was significantly related to total test score.

Multivariate Analyses of Item Types

The results of the multivariate analyses of item type scores (Table 15) and item contrasts (Table 16) echo the results of the univariate analysis of total test scores. Both multivariate analyses reveal a treatment effect significant at the .05 level. The univariate analysis of scores on item Type III suggests that the treatment effect revealed by the multivariate analyses is due to differential performance on this item type. The univariate analysis of contrasts shows that performance on item Type III is significantly different from performance on both item Type I and item Type II. The multivariate analyses did not reveal a significant cognitive style effect or treatment by cognitive style interaction.

Table 13

Number of Subjects in Each Experimental Group by Sex and Observed Means and Standard Deviations for the Three Item Types and Total Score in Study II

Treatment	Item Type	Cognitive Style: Impulsive Males	Impulsive Females	Reflective Males	Reflective Females	M
Discovery	1	29.33 (4.18)	25.50 (5.95)	27.00 (5.89)	29.50 (8.78)	27.71
	2	24.83 (6.18)	25.25 (6.54)	21.25 (6.02)	25.00 (5.26)	24.42
	3	31.67 (5.01)	31.13 (3.14)	28.75 (2.50)	33.67 (9.18)	31.50
	Total	85.83 (12.45) N = 6 (0)	81.87 (10.60) N = 8 (1)	77.00 (11.58) N = 4 (4)	88.17 (16.01) N = 6 (2)	83.63 N = 24
Expository	1	26.00 (4.30)	29.33 (4.72)	31.63 (4.31)	29.57 (5.19)	29.45
	2	22.20 (5.89)	26.00 (7.89)	27.50 (3.89)	25.57 (5.71)	25.66
	3	36.20 (7.05)	36.33 (5.07)	37.75 (5.28)	41.86 (3.85)	38.03
	Total	84.40 (12.12) N = 5 (0)	91.67 (14.48) N = 9 (0)	96.88 (10.29) N = 8 (0)	97.00 (10.08) N = 7 (2)	93.14 N = 29
M	1	27.64		29.80		
	2	24.86		25.36		
	3	33.82		36.48		
	Total	86.32 N = 28		91.64 N = 25		

Note.--Standard deviations and number of Ss lost are given in parentheses.

Table 14

Univariate Analysis of Covariance of Total Test Scores in Study II

Source	df	MS	F	p<
IQ (Covariate)	1	1297.07	10.27	.003*
Analysis of Covariance				
Sex	1	55.11	.44	.51
Cognitive Style	1	176.25	1.39	.24
Sex x Cognitive Style	1	.31	.002	.96
Treatment	1	616.80	4.88	.03*
Treatment x Cognitive Style	1	259.73	2.05	.16
Treatment x Sex and Treatment x Sex x Cognitive Style	2	45.95	.36	.70
Between Subjects within Cells (Error)	45	126.42		

*Significant at or beyond the .05 level chosen.
Note.--All effects were tested in the order presented.

Table 15

Multivariate Analysis of Covariance of Item Type Scores in Study II

Source	df	Multivariate	Univariate Type I	Univariate Type II	Univariate Type III
IQ (Covariate)	3	<.004*	<.04*	<.002*	<.26
Analysis of Covariance					
Sex	3	<.71			
Cognitive Style	3	<.32	<.30	<.84	<.11
Sex x Cognitive Style	3	<.17			
Treatment	3	<.002*	<.57	<.92	<.0003*
Treatment x Cognitive Style	3	<.53			
Treatment x Sex and Treatment x Sex x Cognitive Style	6	<.84			
Between Subjects within Cells (Error)	45	MS = 152.46	30.41	38.52	29.41

*Significant at or beyond the .05 level chosen.
Note.--All effects were tested in the order presented.

Table 16

Multivariate Analysis of Covariance of Contrasts

Between Item Type Scores in Study II

Source	df	Multivariate	Univariate Type 3-1	Univariate Type 3-2
IQ (Covariate)	2	<.14		
Analysis of Variance (IQ not removed)				
Sex	2	<.54		
Cognitive Style	2	<.46		
Sex x Cognitive Style	2	<.29		
Treatment	2	<.003	<.008*	<.003*
Treatment x Cognitive Style	2	<.77		
Treatment x Sex and Treatment x Sex x Cognitive Style	2	<.79		
Between Subjects within Cells (Error)	58	MS = 374.68	41.00	39.71

*Significant at or beyond the .05 chosen level.
Note.--All effects were tested in the order presented.

Table 17

Estimated Combined Means for Item Type III and Total Test Score for Treatment

by Cognitive Style Groups in Study II

Treatment			Cognitive Style: Impulsive	Cognitive Style: Reflective	M
	Discovery	Item Type III	31.40	31.21	31.30
		Total	83.85	82.58	83.22
			N = 14	N = 10	N = 24
	Expository	Item Type III	36.27	39.80	38.04
		Total	88.03	96.94	92.49
			N = 14	N = 15	N = 29
			33.83	35.51	
			85.94	89.76	
			N = 28	N = 25	

From these three analyses it can be concluded that there is a difference between treatments. Expository lessons resulted in higher performance than discovery lessons. The difference in performance resulting from these two lessons appears to reflect a difference in Ss' ability to infer the concepts as assessed by item Type III. Thus, hypothesis 2 is supported.

There was no support for the hypothesis that reflective Ss would perform significantly better than impulsive Ss on the attainment of formal levels of the concepts.

The third hypothesis, that impulsive Ss would benefit more from expository lessons than reflective Ss, receives no support in any of the three analyses. Table 17 presents the estimated means for total score and item Type III scores for each treatment by cognitive style group. The difference between expository and discovery treatments on total score was 4.18 for impulsive Ss, and 14.36 for reflective Ss. The difference between expository and discovery treatments on item Type III was 4.87 for impulsive Ss, and 8.59 for reflective Ss. In both cases it appears that reflective Ss benefited more from the expository lessons than did impulsive Ss. Thus, the pattern of means is actually opposite from that predicted. The means of each treatment by cognitive style group for total test score and item Type III are illustrated in Figures 3 and 4.

Correlations Among Selected Dependent Variables

Table 18 presents correlations among MFF errors, MFF latencies, reading and arithmetic achievement as assessed by the Iowa Test of Basic

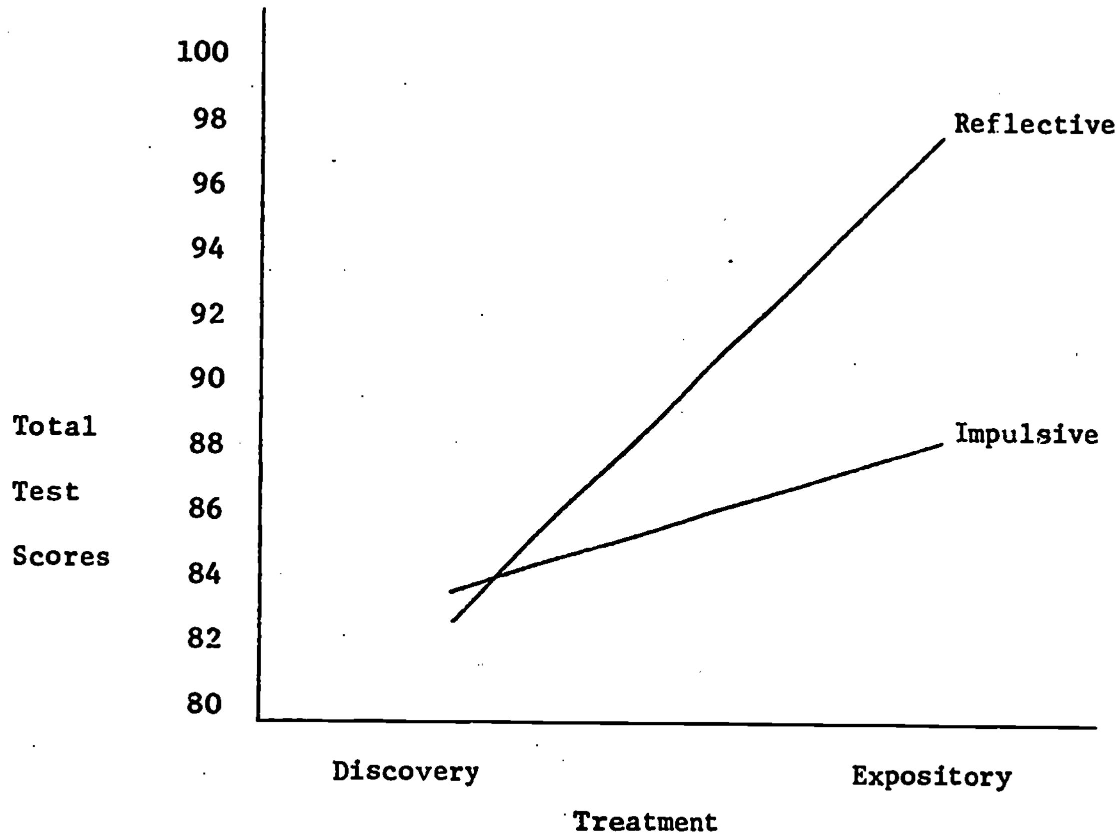

Fig. 3. Estimated means of total test score for reflective and impulsive Ss under discovery and expository treatment conditions.

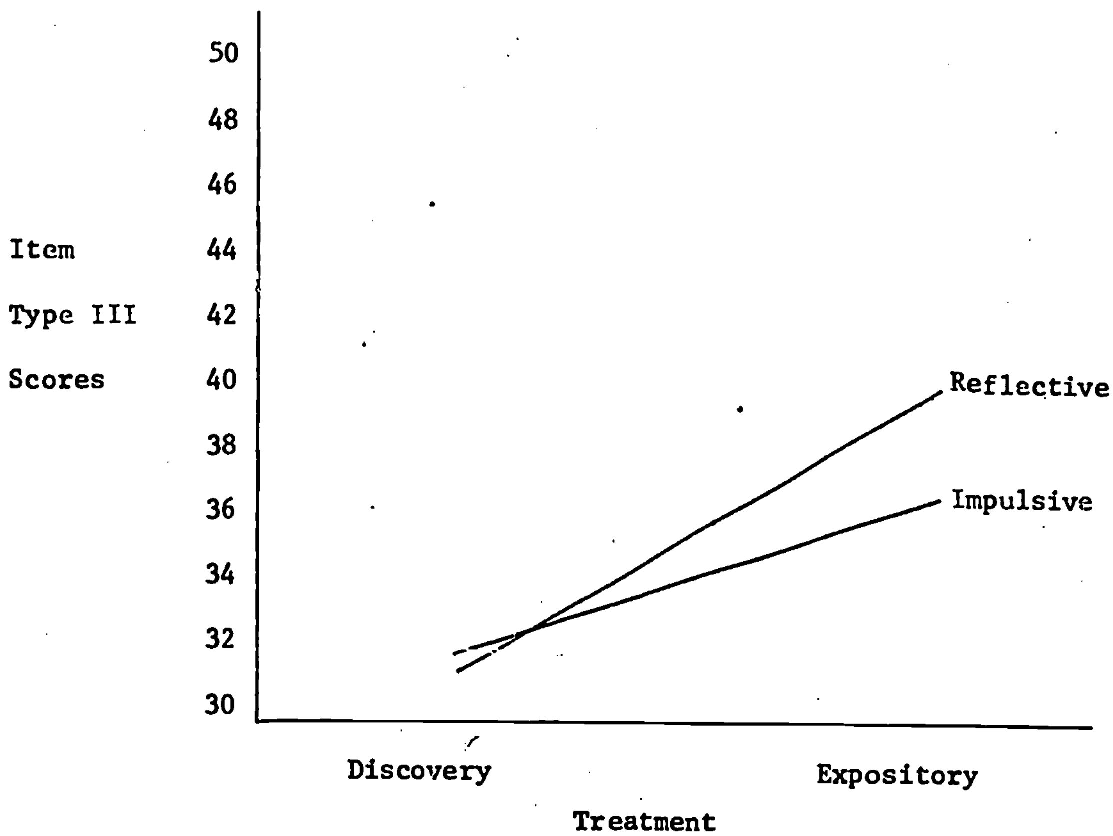

Fig. 4. Estimated means of item Type III scores for reflective and impulsive Ss under discovery and expository treatment conditions.

Skills, Kuhlmann-Anderson IQs and total score on the Test of Geometry Knowledge: From PRT.

Performance on the geometry test appears to be related to reading achievement, arithmetic achievement, and IQ. The correlation between MFF errors and MFF latency (-.72) is at the upper range of correlations reported by Kagan, et al. (1964). It appears that neither MFF errors nor MFF latencies is significantly related to reading or arithmetic achievement, IQ, or performance on the geometry test.

Comparison of Times Taken to Complete the Lessons

If the reflective tempo is evident across various tasks it could be predicted that the disposition of reflective Ss to take a longer time studying the alternatives on the MFF would be reflected in the time taken to study the geometry lessons. This prediction was not supported. Reflective Ss studying the discovery lesson took an average of 17.1 minutes, while impulsive Ss took 18.4 minutes. Reflective Ss studying the expository lesson took 4.6 minutes, while impulsive Ss took 5.3 minutes. In both cases the means of the impulsive Ss were slightly greater than means of reflective Ss.

Table 18

Correlations Among Selected Dependent Variables

for the 53 Ss in Study II

		Time	Errors	Reading	Arithmetic	IQ	PRT
1	MFF Time	1.00					
2	MFF Errors	-.72*	1.00				
3	Reading Achievement	.05	-.17	1.00			
4	Arithmetic Achievement	.10	-.19	.71*	1.00		
5	IQ	.01	-.14	.57*	.60*	1.00	
6	Total PRT Score	.04	-.20	.48*	.45*	.50*	1.00

Note.--Correlations <-.45 or >.45 are significant at the .05 level for a two-tailed test.

Chapter V

DISCUSSION AND CONCLUSIONS

Discussion

These studies sought to identify two learning styles, defined as interactions between organismic variables and instructional method. The organismic variables were selected by hypothesizing which organismic variables are related to two cognitive operations involved in the attainment of a concept at the formal level, discriminating attributes and inferring the concept. It was hypothesized that the analytic-global cognitive style would affect discrimination of attributes and the reflectivity-impulsivity cognitive style would affect inference of the concept. As a test of the effect of cognitive style on these operations, lessons were devised which increased or decreased the degree to which these operations were necessary.

Study I dealt with the effect of the analytic-global cognitive style on discrimination of attributes. It was hypothesized that analytic Ss would discriminate attributes better than non-analytic Ss. An emphasis condition which drew attention to the relevant attributes was incorporated into written materials in an attempt to compensate for non-analytic Ss' inability to discriminate attributes.

Study II dealt with the effect of the reflectivity-impulsivity cognitive style on inference of the concept definition. It was hypothesized

that reflective Ss would be better able to infer the concept definition because they tend to take time to judge the validity of hypotheses. Impulsive Ss could be helped by removing the necessity of making inferences, i.e., by stating the relevant attributes of the concepts.

It was found that the performance of analytic Ss was superior to the performance of global Ss. This result was obtained when the total test score was the dependent measure and when the score on item Type I which assessed discrimination of attributes was the dependent measure. Ss studying the emphasis lesson performed better than Ss studying the no emphasis lesson. This result was significant at the .08 level for the analysis performed on the total test score and .02 for the analysis performed on the item type which assessed discrimination of attributes.

The only significant result found in Study II was the main effect of treatment. The expository lesson produced achievement which was superior to the discovery lesson. This result supports the results obtained by Nelson and Frayer (1972). The treatment effect was most evident on items which assessed Ss' ability to infer the concept. Ss required less time to complete the expository lessons than the discovery lessons. Ss spent an average of 18 minutes on the discovery lessons and 5 minutes on the expository lessons.

The failure to obtain a significant interaction between treatment and cognitive style in either study was disappointing. However, it was consistent with the failure of others to find such interactions. Glaser (1972) echoes the belief of other researchers studying the aptitude-treatment interaction (ATI) that the failure to find significant interactions

is due, in part, to the choice of general measures of aptitude or organismic variables.

> These measures derived from a psychometric, selection-oriented tradition do not appear to relate to the processes of learning and performance that have been under investigation in experimental and developmental psychology. The treatments investigated in the ATI studies were not generated by any systematic analyses of the kinds of psychological processes called upon in particular instructional methods and individual differences were not assessed in terms of these processes (p. 8).

In these studies, however, care was taken to avoid some of these criticisms. First, both the organismic variables and the treatments were directly related to processes involved in concept learning. Secondly, the measures used to assess effects were devised to specifically assess differences in both the treatment conditions and organismic variables. Thus, failure to relate the treatment condition to the organismic variable or failure to use a specific dependent measure would not seem to account for the lack of significant aptitude by treatment interactions in this study.

One possible factor account for the lack of significant interaction may have been the characteristics of the tests used to measure performance. The dependent measures used in the studies were internally consistent. The reliabilities were adequate and content validity was judged to be high. However, difficulty indices were not as high as would be desirable. This was especially true of item Type I, which assessed the discrimination of attributes given the name of the attribute. It is difficult to control the difficulty of this type of item, i.e., to make this type more difficult. Consequently, there may have been a ceiling effect on this item

type for some groups in Study I. In Study I the mean scores on this item type were quite high, ranging from a low of 25.50 for non-analytic females studying no emphasis lessons to a high of 34.00 for analytic males studying emphasis lessons. The overall difficulty of item Types I and II was generally greater.

A second possible explanation for the absence of hypothesized results is that while the dependent measures were related to the independent measures, they may not have been uncontaminated measures of the operations under investigation. Thus, while item Type I required S to discriminate attributes, it also required S to associate the label with the attribute. Likewise, while item Type III required S to infer the concept by recognizing relevant attributes, performance on it was also dependent upon S's ability to associate the label with the attributes and to associate written descriptions of the concepts with attributes which had been presented pictorially for the most part.

The predisposition to respond impulsively or reflectively operates in situations in which alternative hypotheses are available. Alternative hypotheses were available during the learning of the concepts from the discovery lessons. Alternative hypotheses were also available on the test. Thus, the scores on the dependent measures may have reflected differences between reflective and impulsive Ss in their style of responding as well as in their concept learning. The reflective Ss may have studied alternatives before responding while the impulsive Ss may have chosen responses without first testing the validity of each response. Small differences between reflective and impulsive Ss could be a result

of an interaction between responding styles and the difficulty of the items. On an easy item the probability of answering correctly would be high. A person responding impulsively would have a good chance of answering the easy item correctly. Thus, there would be little difference between the performance of impulsive and reflective Ss on easy items. The fact that some of the items were easy may, in part, account for the lack of a strong main effect of cognitive style in Study II.

It would be possible to infer whether scores represented differences between responding styles by (a) examining the time spent responding to test items, and (b) by using a multiple choice format in addition to a true-false format. In the present study no difference was found between reflective and impulsive Ss in the time spent studying lessons. However, there may have been differences between groups on the time spent responding to the items. If reflective Ss took considerably longer to respond than impulsive Ss it could be inferred that differences in scores resulted, in part, from differences in responding styles. If there was no difference between groups on the time spent completing the test, it could be inferred that differences in scores reflected differences in learning. A second way of determining whether scores reflected differences in operations involved in learning or differences in operations involved in responding would be to increase the number of alternative hypotheses in each test question. If scores were dependent on responding styles it would follow that larger differences between reflective and impulsive Ss would appear on a test composed of items with several foils, i.e., a multiple choice test than on a test composed of items with only two possible answers, i.e., a true-false test.

Other explanations for the obtained results may lie with the independent variables. The instructional methods were designed to vary the necessity of performing the operations under investigation. Thus, the no emphasis lesson required maximum discrimination of attributes, while the emphasis lesson required minimal discrimination of attributes. Likewise, the discovery lesson required maximum inference of the concept definition, while the expository lesson required minimal inference of the concept definition. There appeared to be a large difference in performance between discovery and expository groups and a smaller difference between emphasis and no emphasis groups as evidenced by mean performance.

The organismic variables were chosen by inferring which were related to the operations under investigation. Both variables have been reliably measured and consistently found to affect performance on various tasks. However, these variables may not reflect potent variables. Recent reviews of the literature on individual difference variables and aptitude by treatment interaction studies suggest that there may be three pervasive factors of individual difference variables. These are general ability, introversion-extroversion, and anxiety (Farley, personal communication). Factor analyses have revealed that other individual difference variables load on these three, and ATI studies have revealed that variables related to introversion-extroversion and anxiety are more likely to produce interactions than other variables. Perhaps the variables chosen for these studies were too factorially impure to produce interactions.

From this discussion it appears that it is not one particular overwhelming reason which accounts for the absence of interactions. It may

be a combination of several factors. For example, in Study I differences between analytic and global Ss were great but differences between emphasis and no emphasis treatments were not great. And in Study II differences between reflective and impulsive Ss were not great but differences between expository and discovery treatments were great. To obtain an interaction between aptitude variables and treatment variables not only should the independent and dependent variables be related in terms of underlying operations as suggested by Glaser (1972), but in addition, the treatments should differ in terms of the operations under investigation, the organismic variables should reflect basic underlying traits or processes, and the dependent measures should be valid uncontaminated measures of the operations under investigation.

Conclusions

The main conclusion of these studies is that there are characteristics of individuals, in addition to ability, which may affect learning in the classroom. It was found that Ss who were able to perceptually separate a simple figure from a complex background performed significantly better on a test assessing attainment of geometry concepts, especially on items assessing discrimination of relevant attributes than Ss deficient in this ability.

Recognizing these differences it seems reasonable to attempt to compensate for them. Two approaches are possible, training the non-analytic S to be more analytic, or modifying the instructional materials to accommodate these differences. The first attempt has met with minimal success. These studies attempted to modify the instructional materials

and also had minimal success. The treatment by cognitive style interactions was not significant. However, a look at the means suggested that manipulating treatment did possibly benefit non-analytic _Ss_ in Study I.

Future research should be focused on identifying the most potent of the organismic variables which affect learning. Reliable instruments for assessing these variables should be created. And finally, instructional methods which take into account these variables should be devised. When important characteristics of individuals can be identified and assessed and when materials are created around these variables, learning can truly become individualized.

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APPENDIX A

KNOWLEDGE OF GEOMETRY CONCEPTS QUESTIONNAIRE

As of May 9 what percentage of your students are unfamiliar with, have some knowledge of, or have mastered the following concepts?

	unfamiliar	some knowledge	mastery
1, simple figure	____	____	____
2, plane figure	____	____	____
3. closed figure	____	____	____
4, line segment	____	____	____
5. parallel	____	____	____
6. polygon	____	____	____
7. quadrilateral	____	____	____
8. parallelogram	____	____	____
9. rhombus	____	____	____
10. trapezoid	____	____	____

NAME: ____________________

SCHOOL: ____________________

CLASS PERIOD: ____________________

APPENDIX B

INSTRUCTIONS TO SUBJECTS

Day 1 Instructions

Good morning (afternoon),

My name is ________________. I am working with some educational psychologists at the University of Wisconsin in Madison. These psychologists are trying to find out how to make it easier for students to learn mathematics. They have written some lessons which you will study this week. After you have completed the lessons, you will be given a short test to see how much you learned. Please do the best job you can on both the lessons and the test. If you do, you will learn some geometry and more than that you will help psychologists find ways to make learning easier for other students.

Each of you will receive a packet with a lesson, cardboard strip and ruler in it. You may take everything out, but do not open the lesson.

(Hand out supplies.)

Fill in the information on the front of the lesson. Write your name. Write your teacher's name and the class period where it says teacher. The date is ________________.

(Write teacher's name, the period, and the date on the board.) Don't write anything on the lines which say "starting time" and "finishing time."

This lesson may be different from other lessons you have done. Here is how it works. The pages in your lesson will look like this. (Open to any page.) This side has questions for you to answer. The other side has the correct answers. When you do the lesson you should

cover the answers with the piece of cardboard, like this. After you write your answer to the questions, move the cardboard down just far enough so that you can see if the answer you wrote is correct. (Demonstrate.) If it is correct, go on to the next question. If you make a mistake and find that the answer you wrote down is not right, just draw a line through it and write the correct answer beside it. You may use the ruler anytime you wish.

When I finish with the instructions, you will go through the lesson by yourselves. If you have any questions or come to any words that you do not know, raise your hand and I will help you. If you are not sure of something you have learned, you may look back at a page you have already done.

When you finish, write the exact time where it says "finishing time." Work quietly on your assignment until everyone is finished. Then I will collect your lessons.

Are there any questions? Write the exact time it is now where it says "starting time." (Write the time on the board.) Begin working.

Day 2 Instructions

Good morning (afternoon),

(Distribute materials.)

Does everyone have a pencil, ruler and lesson? Fill in the information on the front cover of the lesson. Put your teacher's name and the class period where it says teacher. Today's date is

____________________.

Today's procedure will be a little different from yesterday's. First of all not all of you will have the same lesson. Don't worry about this. The type of lesson you have has nothing to do with how smart you are. Also, you will not need to use the cardboard strips with these lessons.

Another difference is that after you finish your lesson, you will be given a test.

Now turn to the first page. (Read the first page.)

When I finish with the instructions, you will complete the lesson. When you have finished the lesson, write your finishing time on the front cover and raise your hand. I will collect your lesson and give you a test. Fill in the information on the cover of the test and read the instructions carefully. When you finish the test work on your assignment.

Are there any questions? The starting time is ________________. Begin working.

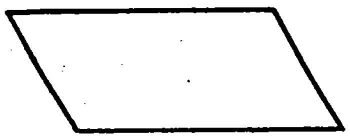
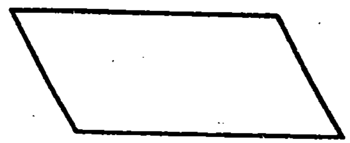
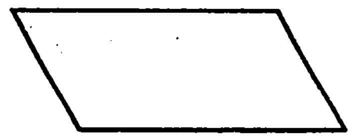
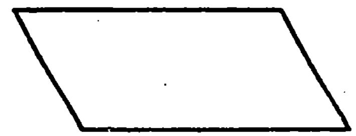
APPENDIX C

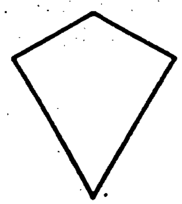
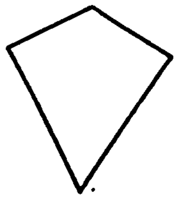
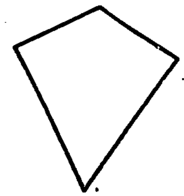
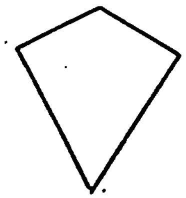
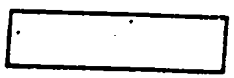
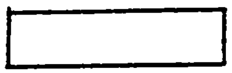
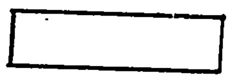
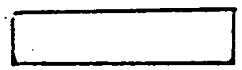
DISCOVERY, EXPOSITORY, EMPHASIS AND NO EMPHASIS GEOMETRY LESSONS

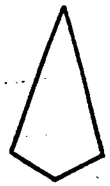
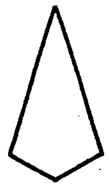
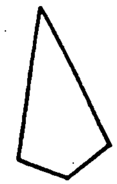
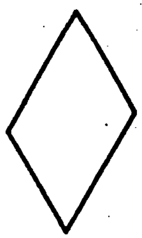
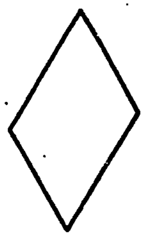
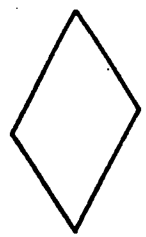
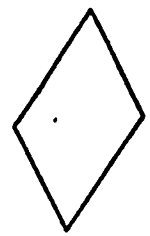
Look carefully at each word as I read it to you. Then say the word aloud with me when I repeat it.
1. parallelogram 2. rhombus 3. trapezoid

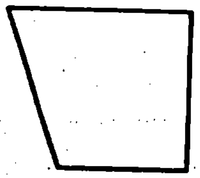
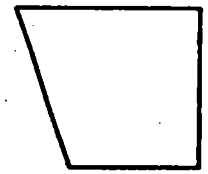
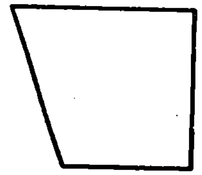
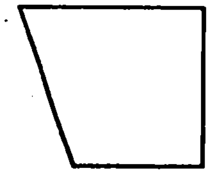
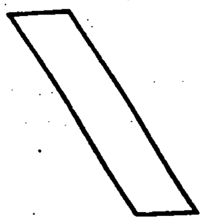
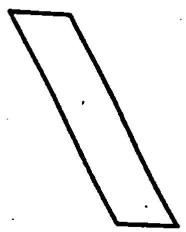
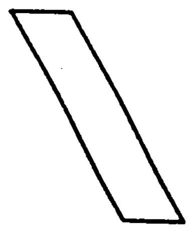
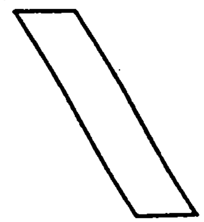
Yesterday you learned about line segments, closed and open figures, simple and non-simple figures, plane and solid figures and how to tell when lines are parallel. You also learned that a quadrilateral is a plane, closed, simple figure made up of four line segments. Today you will learn about three special kinds of quadrilaterals.

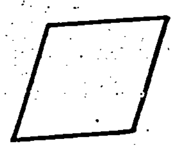
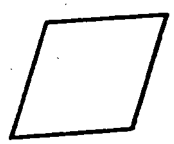
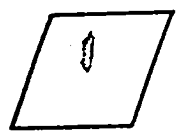
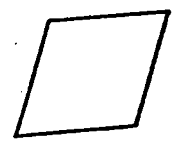
The first type of quadrilateral you will learn about is called a parallelogram. By looking at the next seven figures you will be able to tell whether a quadrilateral is a parallelogram or not.

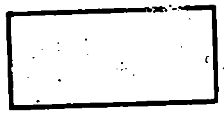
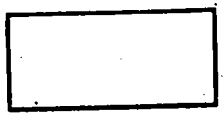
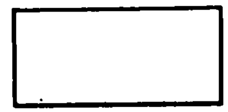
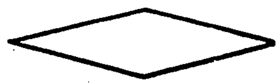
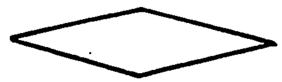
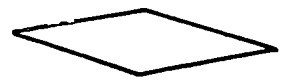
Discovery	Expository	Emphasis	No Emphasis
When you look at the figures notice how they are alike and how they are different.	A parallelogram has two pairs of parallel sides. Opposite sides of a parallelogram are also equal in length.	Pay special attention to pairs of opposite sides.	
1. This figure is a parallelogram. 	This first figure is a parallelogram.  $\overline{AB}$ is parallel to $\overline{DC}$. $\overline{AD}$ is parallel to BC. AB is the same length as DC. AD is the same length as BC. There are two pairs of parallel sides. Opposite sides are equal.	This first figure is a parallelogram.  Is $\overline{AB}$ parallel to $\overline{DC}$?___ Is $\overline{AD}$ parallel to BC?___ Is $\overline{AB}$ the same length as DC?___ Is $\overline{AD}$ the same length as BC?___	This first figure is a parallelogram. 

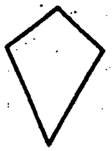
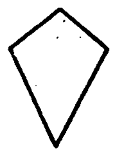
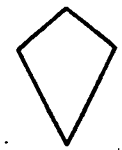
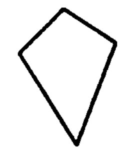
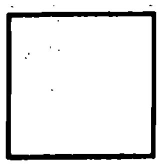
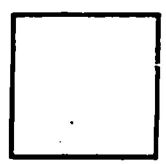
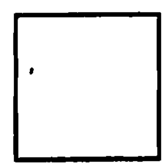
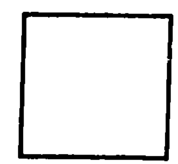
Discovery	Expository	Emphasis	No Emphasis
2. This figure is <u>not</u> a parallelogram.  How is this figure different from the parallelogram in Question 1? __________ __________ __________ __________	This next figure is <u>not</u> a parallelogram.  $\overline{AB}$ is not parallel to DC. AD is not parallel to BC. AB is not the same length as DC. AD is <u>not</u> the same length as BC. There are no pairs of parallel sides. Opposite sides are not equal.	This next figure is <u>not</u> a parallelogram.  Is $\overline{AB}$ parallel to $\overline{DC}$?___ Is $\overline{AD}$ parallel to BC?___ Is $\overline{AB}$ the same length as DC?___ Is AD the same length as BC?___	This next figure is <u>not</u> a parallelogram. 
3. This figure <u>is</u> a parallelogram.  How is this figure like the figure in Question 1 and different from the figure in Question 2? __________ __________	This next figure <u>is</u> a parallelogram.  There are two pairs of parallel sides. Oppcsite sides are equal	This figure <u>is</u> a parallelogram.  How many pairs of parallel sides are there?___ How many pairs of opposite sides are equal?___	This figure <u>is</u> a parallelogram. 

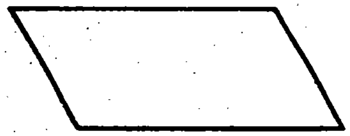
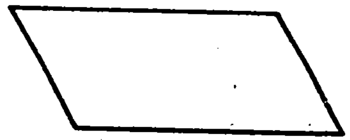
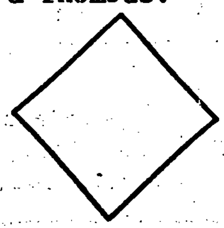
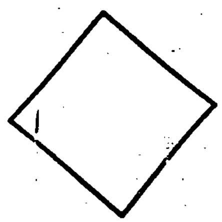
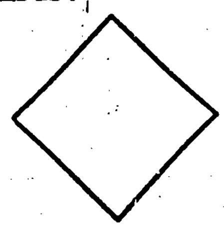
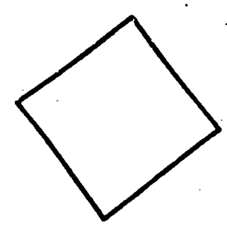
Discovery	Expository	Emphasis	No Emphasis
4. This figure is <u>not</u> a parallelogram.  How is this figure different from the figures in Questions 1 and 3? __________ __________ __________	This figure is <u>not</u> a parallelogram.  There are no pairs of parallel sides. Opposite sides are not equal.	This figure is <u>not</u> a parallelogram.  How many pairs of parallel sides are there?___ How many pairs of opposite sides are equal?___	This figure is <u>not</u> a parallelogram. 
5. This figure <u>is</u> a parallelogram.  How is this figure like the figures in Question 1 and 3 and different from the figures in Questions 2 and 4? ________ __________ __________ __________	This figure <u>is</u> a parallelogram.  There are two pairs of parallel sides. Opposite sides are equal.	This figure <u>is</u> a parallelogram.  How many pairs of parallel sides are there?___ How many pairs of opposite sides are equal?___	This figure <u>is</u> a parallelogram. 

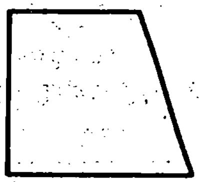
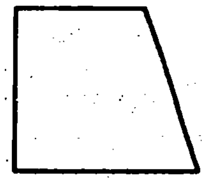
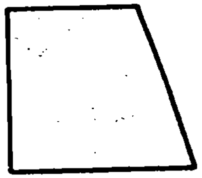
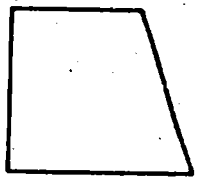
Discovery	Expository	Emphasis	No Emphasis
6. This figure is <u>not</u> a parallelogram.  How is this figure different from the figures in Questions 1, 3 and 5? ______	This next figure is <u>not</u> a parallelogram.  There is only one pair of parallel sides. Opposite sides are not equal.	This next figure is <u>not</u> a parallelogram.  How many pairs of parallel sides are there?___ How many pairs of opposite sides are equal?___	This next figure is <u>not</u> a parallelogram. 
7. This last figure <u>is</u> a parallelogram.  How is this parallelogram like the parallelograms in Questions 1, 3 and 5 and different from the figures in Questions 2, 4 and 6? ______	This last figure <u>is</u> a parallelogram.  There are two pairs of parallel sides. Opposite sides are equal.	This last figure <u>is</u> a parallelogram.  How many pairs of parallel sides are there?___ How many pairs of opposite sides are equal?___	This last figure <u>is</u> a parallelogram 

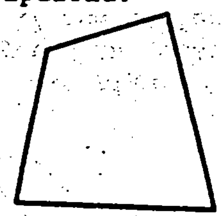
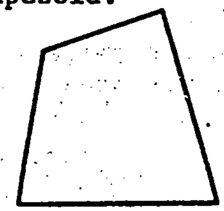
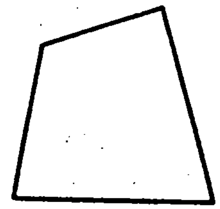
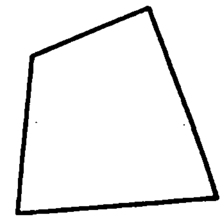
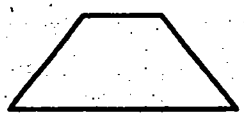
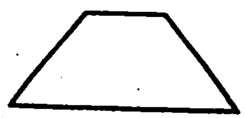
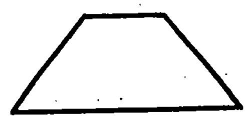
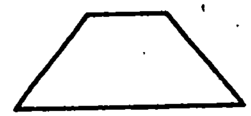
Discovery	Expository	Emphasis	No Emphasis
In the last seven questions (Questions 1-7) four fig- ures were alike in some way. How were they alike? ______ ______ ______ ______			
8. This first figure <u>is</u> a rhombus. 	This first figure <u>is</u> a rhombus.  $\overline{AB} = \overline{DC} = \overline{AD} = \overline{BC}$. (= means equal to)	This first figure <u>is</u> a rhombus.  Is $\overline{AB} = \overline{DC} = \overline{AD} = \overline{BC}$? ______ (= means equal to)	This first figure <u>is</u> a rhombus. 

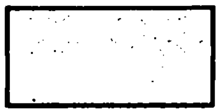
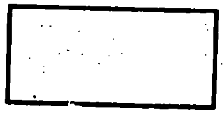
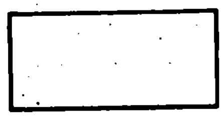
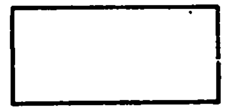
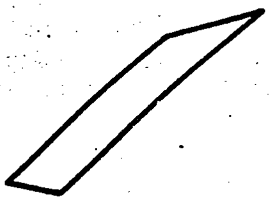
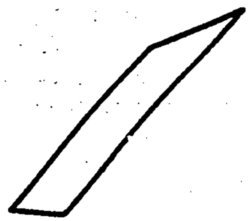
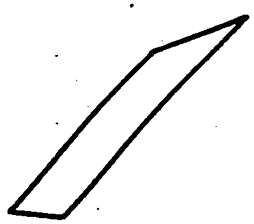
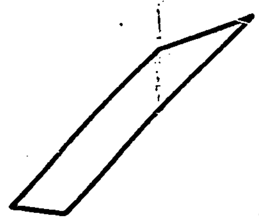
Discovery	Expository	Emphasis	No Emphasis
9. This next figure is <u>not</u> a rhombus.  How is this figure different from the rhombus in Question 8? ____________	This next figure is <u>not</u> a rhombus.  It does not have four sides of equal length.	This next figure is <u>not</u> a rhombus.  Is $\overline{AB} = \overline{BC} = \overline{AD} = \overline{BC}$? ____________	This next figure is <u>not</u> a rhombus. 
10. This figure <u>is</u> a rhombus.  How is this figure like the figure in Question 8 and different from the figure in Question 9? ____________	This figure <u>is</u> a rhombus.  All sides are equal to each other.	This figure <u>is</u> a rhombus.  How many sides are equal to each other? ________	This figure <u>is</u> a rhombus. 

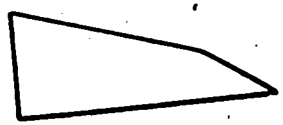
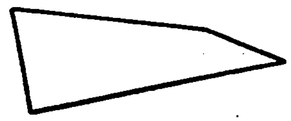
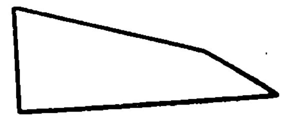
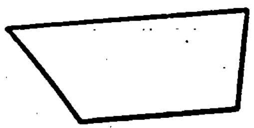
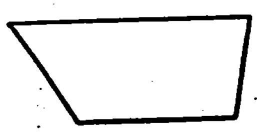
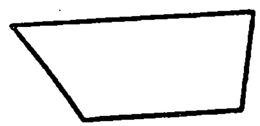
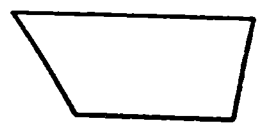
Discovery	Expository	Emphasis	No Emphasis
11. This figure is <u>not</u> a rhombus.  How is this figure different from the figures in Questions 8 and 10? __________ __________ __________	This figure is <u>not</u> a rhombus.  It does not have four sides of equal length.	This figure is <u>not</u> a rhombus.  How many sides are equal to each other? ______	This figure is <u>not</u> a rhombus. 
12. This figure <u>is</u> a rhombus.  How is this figure like the figures in Questions 8 and 10 and different from the figures in Questions 9 and 11? ______ __________ __________	This figure <u>is</u> a rhombus.  All sides are equal to each other.	This figure <u>is</u> a rhombus.  How many sides are equal to each other? ______	This figure <u>is</u> a rhombus. 

Discovery	Expository	Emphasis	No Emphasis
13. This figure is <u>not</u> a rhombus.  How is this figure different from the figures in Questions 8, 10 and 12?	This figure is <u>not</u> a rhombus.  It does not have four sides of equal length.	This figure is <u>not</u> a rhombus.  How many sides are equal to each other?	This figure is <u>not</u> a rhombus. 
14. This last figure <u>is</u> a rhombus.  How is this rhombus like the rhombuses in Questions 8, 10 and 12 and different from the figures in Questions 9, 11 and 13?	This last figure <u>is</u> a rhombus.  All sides are equal to each other.	This last figure <u>is</u> a rhombus.  How many sides are equal to each other?	This last figure <u>is</u> a rhombus. 

Discovery	Expository	Emphasis	No Emphasis
In the last seven questions (Questions 8-14) four figures were alike in some way. How were they alike? ____________________ ____________________ ____________________			
15. This first figure <u>is</u> a trapezoid. 	This first figure <u>is</u> a trapezoid.  $\overline{AB}$ is parallel to $\overline{DC}$. __ AD is not parallel to $\overline{BC}$. There is one pair of parallel sides.	This first figure <u>is</u> a trapezoid.  Is $\overline{AB}$ parallel to $\overline{DC}$? __ Is AD parallel to BC? __	This first figure <u>is</u> a trapezoid. 

Discovery	Expository	Emphasis	No Emphasis
16. This figure is <u>not</u> a trapezoid.  How is this figure different from the trapezoid in Question 15? ____________ ____________ ____________	This figure is <u>not</u> a trapezoid.  $\overline{AB}$ is not parallel to $\overline{DC}$. $\overline{AD}$ is not parallel to $\overline{BC}$. There are no pairs of parallel sides.	This figure is <u>not</u> a a trapezoid.  Is $\overline{AB}$ parallel to $\overline{DC}$? ___ Is $\overline{AD}$ parallel to $\overline{BC}$? ___	This figure is <u>not</u> a trapezoid. 
17. This figure <u>is</u> a trapezoid.  How is this figure like the figure in Question 15 and different from the figure in Question 16? ____________ ____________ ____________	This figure <u>is</u> a trapezoid.  This figure has one pair of parallel sides.	This figure <u>is</u> a trapezoid.  How many pairs of parallel sides are there? ____________	This figure <u>is</u> a trapezoid. 

Discovery	Expository	Emphasis	No Emphasis
18. This figure is <u>not</u> a trapezoid.  How is this figure different from the figures in Questions 15 and 17? ____ ____ ____	This figure is <u>not</u> a trapezoid.  This figure has two pairs of parallel sides.	This figure is <u>not</u> a trapezoid.  How many pairs of parallel sides are there? ___	This figure is <u>not</u> a trapezoid. 
19. This next figure <u>is</u> a trapezoid.  How is this figure like the figures in Questions 15 and 17 and different from the figures in Questions 16 and 18? ____ ____ ____	This next figure <u>is</u> a trapezoid.  This figure has one pair of parallel sides.	This next figure <u>is</u> a trapezoid. 	This next figure <u>is</u> a trapezoid. 

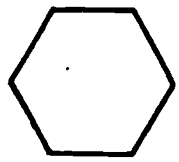
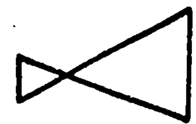
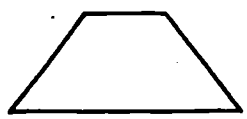
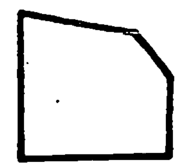
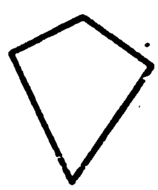
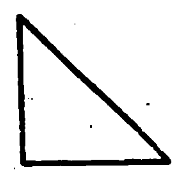
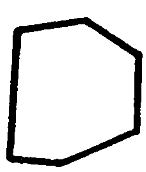
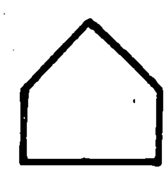
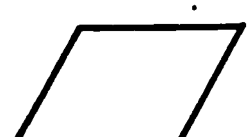
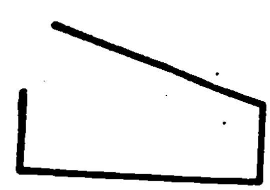
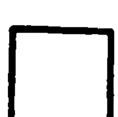
Discovery	Expository	Emphasis	No Emphasis
20. This figure is <u>not</u> a trapezoid.  How is this figure different from the figures in Questions 15 and 17 and 19? ________	This figure is <u>not</u> a trapezoid.  This figure has no pairs of parallel sides.	This figure is <u>not</u> a trapezoid.  How many pairs of parallel sides are there? ___	This figure is <u>not</u> a trapezoid. 
21. This is the last figure.  How is this trapezoid like the trapezoids in Questions 15, 17 and 19 and different from the figures in Questions 16, 18 and 20? ________	This last figure <u>is</u> a trapezoid.  It has one pair of parallel sides.	This last figure <u>is</u> a trapezoid.  How many pairs of parallel sides are there? ________	This last figure <u>is</u> a trapezoid. 

Discovery	Expository	Emphasis	No Emphasis
In the last seven questions (Questions 15-21) four figures were alike in some way. How were they alike? ______			

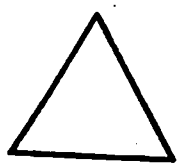
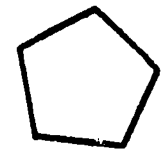
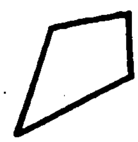
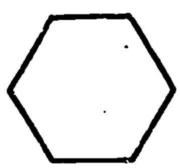
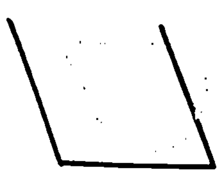
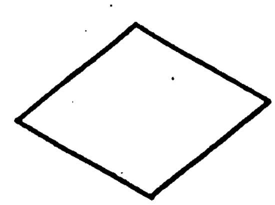
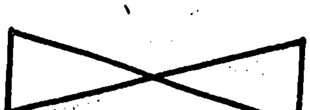
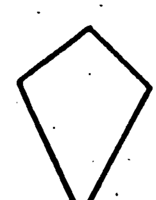
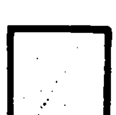
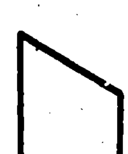
APPENDIX D

TEST OF GEOMETRY KNOWLEDGE: FORM PRT

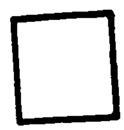
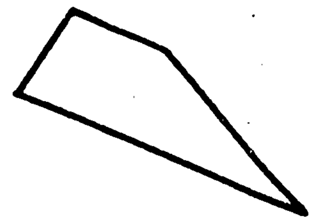
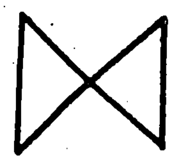
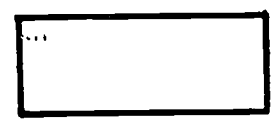
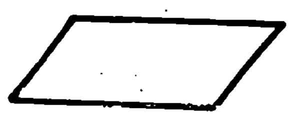
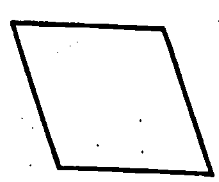
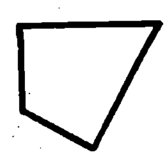
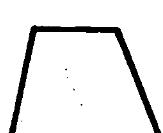
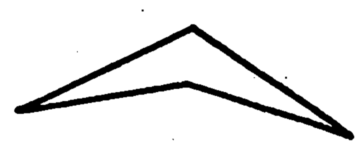
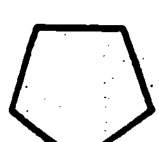
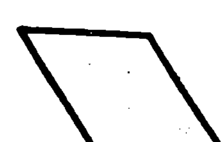
If the figure has one and only one pair of parallel sides, circle Yes. If it doesn't, circle No.

1.		Yes No	7.		Yes No
2.		Yes No	8.		Yes No
3.		Yes No	9.		Yes No
4.		Yes No	10.		Yes No
5.		Yes No	11.		Yes No
6.		Yes No	12.		Yes No

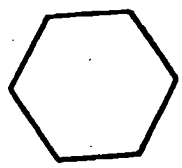
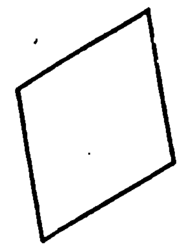
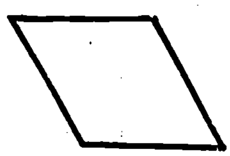
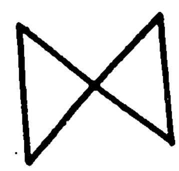
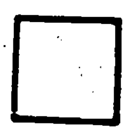
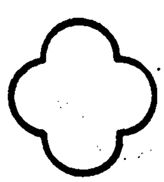
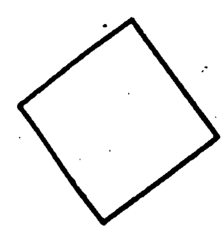
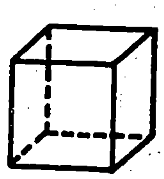
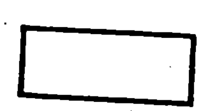
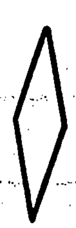
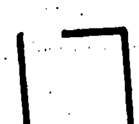
If the figure has all sides of equal length, circle Yes. If it doesn't, circle No.

1.		Yes No	7.		Yes No
2.		Yes No	8.		Yes No
3.		Yes No	9.		Yes No
4.		Yes No	10.		Yes No
5.		Yes No	11.		Yes No
6.		Yes No	12.		Yes No

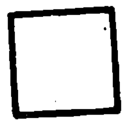
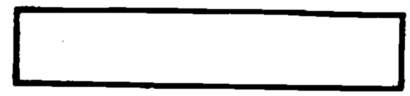
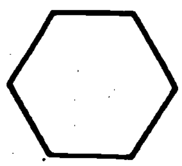
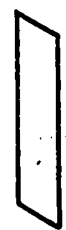
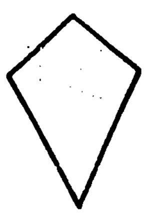
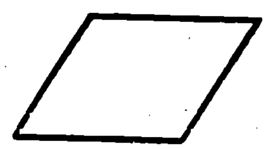
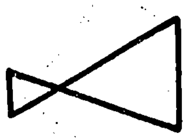
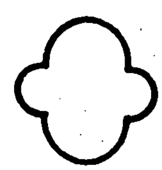
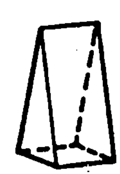
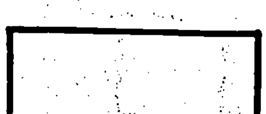
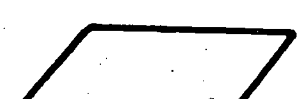
If the figure has two pairs of parallel sides, circle Yes. If it doesn't, circle No.

1.		Yes No	7.		Yes No
2.		Yes No	8.		Yes No
3.		Yes No	9.		Yes No
4.		Yes No	10.		Yes No
5.		Yes No	11.		Yes No
6.		Yes No	12.		Yes No

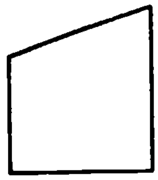
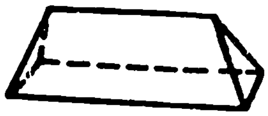
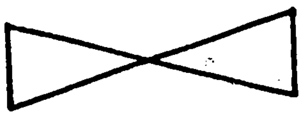
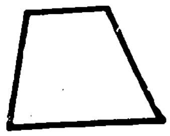
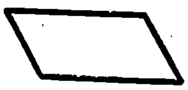
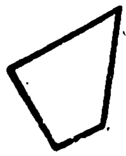
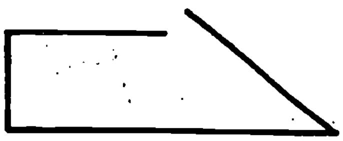
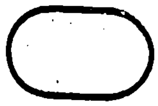
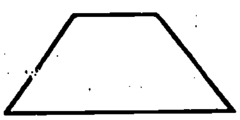
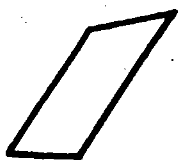
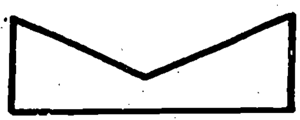
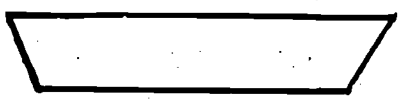
If the figure is a rhombus, circle Yes. If it isn't, circle No.

1.		Yes No	7.		Yes No
2.		Yes No	8.		Yes No
3.		Yes No	9.		Yes No
4.		Yes No	10.		Yes No
5.		Yes No	11.		Yes No
6.		Yes No	12.		Yes No

If the figure is a <u>parallelogram</u>, circle Yes. If it isn't, circle No.

1.		Yes No	7.		Yes No
2.		Yes No	8.		Yes No
3.		Yes No	9.		Yes No
4.		Yes No	10.		Yes No
5.		Yes No	11.		Yes No
6.		Yes No	12.		Yes No

If the figure is a <u>trapezoid</u>, circle Yes. If it isn't, circle No.

1. 	Yes No	7. 	Yes No
2. 	Yes No	8. 	Yes No
3. 	Yes No	9. 	Yes No
4. 	Yes No	10. 	Yes No
5. 	Yes No	11. 	Yes No
6. 	Yes No	12. 	Yes No

If the sentence is true of all parallelograms, circle Yes. If it isn't, circle No.

Yes	No	1.	All sides are equal in length.
Yes	No	2.	They are open figures.
Yes	No	3.	They are polygons.
Yes	No	4.	They are simple figures.
Yes	No	5.	Opposite sides are equal in length.
Yes	No	6.	They have two pairs of parallel sides.
Yes	No	7.	They are non-simple figures.
Yes	No	8.	They are closed figures.
Yes	No	9.	They have one and only one pair of parallel sides.
Yes	No	10.	They are plane figures.
Yes	No	11.	They are quadrilaterals.
Yes	No	12.	They are made of four line segments.
Yes	No	13.	They are solid figures.
Yes	No	14.	They have one and only one pair of sides of equal length.
Yes	No	15.	They have no pairs of parallel sides.
Yes	No	16.	No pairs of opposite sides are equal in length.
Yes	No	17.	All parallelograms are also rhombuses.
Yes	No	18.	All parallelograms are also trapezoids.

If the sentence is true of <u>all trapezoids</u>, circle Yes. If it isn't, circle No.

Yes	No	1.	They are made of four line segments.
Yes	No	2.	All sides are equal in length.
Yes	No	3.	They are open figures.
Yes	No	4.	They have one and only one pair of parallel sides.
Yes	No	5.	Opposite sides are equal in length.
Yes	No	6.	They are quadrilaterals.
Yes	No	7.	They are plane figures.
Yes	No	8.	They are non-simple figures.
Yes	No	9.	They have no pairs of parallel sides.
Yes	No	10.	They are simple figures.
Yes	No	11.	They have two pairs of parallel sides.
Yes	No	12.	They are closed figures.
Yes	No	13.	They are solid figures.
Yes	No	14.	They are polygons.
Yes	No	15.	No pairs of opposite sides are equal in length.
Yes	No	16.	They have one and only one pair of sides of equal length.
Yes	No	17.	All trapezoids are also rhombuses.
Yes	No	18.	All trapezoids are also parallelograms

If the sentence is true of <u>all rhombuses</u>, circle Yes. If it isn't, circle No.

Yes	No	1.	They have two pairs of parallel sides.
Yes	No	2.	They are simple figures.
Yes	No	3.	They are solid figures.
Yes	No	4.	Opposite sides are equal in length.
Yes	No	5.	They are open figures.
Yes	No	6.	All sides are equal in length.
Yes	No	7.	They are made of four line segments.
Yes	No	8.	They are quadrilaterals.
Yes	No	9.	They have one and only one pair of sides of equal length.
Yes	No	10.	They are closed figures.
Yes	No	11.	They have one and only one pair of parallel sides.
Yes	No	12.	They are non-simple figures.
Yes	No	13.	They are polygons.
Yes	No	14.	They have no pairs of parallel sides.
Yes	No	15.	No pairs of opposite sides are equal in length.
Yes	No	16.	They are plane figures.
Yes	No	17.	All rhombuses are also trapezoids.
Yes	No	18.	All rhombuses are also parallelograms.

APPENDIX E

OBSERVED MEANS AND STANDARD DEVIATIONS OF IQ SCORES FOR COGNITIVE STYLE BY TREATMENT GROUPS IN STUDIES I AND II

Study 1

Treatment	Cognitive Style: Analytic Males	Analytic Females	Non-Analytic Males	Non-Analytic Females	M
Emphasis	113.14 (15.54) N=7	115.55 (8.14) N=11	100.00 (13.11) N=8	100.25 (7.30) N=8	107.79 N=34
No Emphasis	107.67 (2.37) N=6	113.60 (7.44) N=10	95.00 (12.02) N=9	99.88 (11.70) N=8	104.12 N=33
M	113.09 N=34		98.67 N=33		

Note.---Standard deviations are given in parentheses.

Study II

Treatment	Cognitive Style				M
	Impulsive		Reflective		
	Males	Females	Males	Females	
Discovery	108.17 (15.43) N=6	87.63 (36.92) N=8	95.00 (18.38) N=4	109.17 (10.17) N=6	99.38 N=24
Expository	99.60 (12.82) N=5	108.11 (12.48) N=9	109.25 (15.18) N=8	110.29 (13.43) N=7	107.48 N=29
M	100.75 N=28		107.24 N=25		

Note.---Standard deviations are given in parentheses.

National Evaluation Committee

Helen Bain
Immediate Past President
National Education Association

Lyle E. Bourne, Jr.
Institute for the Study of Intellectual Behavior
Universiy of Colorado

Jeanne S. Chall
Graduate School of Education
Harvard University

Francis S. Chase
Department of Education
University of Chicago

George E. Dickson
College of Education
University of Toledo

Hugh J. Scott
Superintendent of Public Schools
District of Columbia

H. Craig Sipe
Department of Instruction
State University of New York

G. Wesley Sowards
Dean of Education
Florida International University

Benton J. Underwood
Department of Psychology
Northwestern University

Robert J. Wisner
Mathematics Department
New Mexico State University

Executive Committee

William R. Bush
Director of Program Planning and Management
and Deputy Director, R & D Center

Herbert J. Klausmeier, Committee Chairman
Director, R & D Center

Wayne Otto
Principal Investigator
R & D Center

Robert G. Petzold
Professor of Music
University of Wisconsin

Richard A. Rossmiller
Professor of Educational Administration
University of Wisconsin

James E. Walter
Coordinator of Program Planning
R & D Center

Russell S. Way, ex officio
Program Administrator, Title III ESEA
Wisconsin Department of Public Instruction

Faculty of Principal Investigators

Vernon L. Allen
Professor of Psychology

Frank H. Farley
Associate Professor
Educational Psychology

Marvin J. Fruth
Associate Professor
Educational Administration

John G. Harvey
Associate Professor
Mathematics

Frank H. Hooper
Associate Professor
Child Development

Herbert J. Klausmeier
Center Director
V. A. C. Henmon Professor
Educational Psychology

Stephen J. Knezevich
Professor
Educational Administration

Joel R. Levin
Associate Professor
Educational Psychology

L. Joseph Lins
Professor
Institutional Studies

Wayne Otto
Professor
Curriculum and Instruction

Thomas A. Romberg
Associate Professor
Curriculum and Instruction

Peter A. Schreiber
Assistant Professor
English

Richard L. Venezky
Associate Professor
Computer Science

Alan M. Voelker
Assistant Professor
Curriculum and Instruction

Larry M. Wilder
Assistant Professor
Communication Arts